

Assessment of energy expenditure in postpartum women with prior gestational diabetes mellitus: Subjective versus objective methods



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ABSTRACT

Background: Regular physical activity (PA) attenuates the development of type 2 diabetes mellitus in postpartum women with prior gestational diabetes mellitus (GDM). PA is assessed by calculating the energy expenditure (EE), thus accurate estimation of EE is crucial. International PA Questionnaire (IPAQ) and activity diary are widely used subjective methods while pedometer provides objective evidence of PA and EE. **Aims and Objectives:** This study aims to compare subjective and objective methods of assessing EE as a measure of PA in postpartum women with a history of GDM. **Materials and Methods:** Fifty postpartum women who had a history of GDM were advised to maintain activity diaries and pedometer readings for 1 week each month up to 1 year and IPAQ was administered at the end of 6 and 12 months. EE was calculated by all three methods separately and Bland-Altman plots were used to assess the level of agreement between IPAQ and the other tools at 6 and 12 months. Friedman test was performed to compare estimated EE between the three methods. **Results:** There was a poor agreement between the subjective and objective methods. According to Bland-Altman plot results, the highest mean difference was observed between IPAQ and pedometer at 12 months (mean difference was 75.9). This observation indicated an underestimation of pedometer values at 12 months. EE assessed by two subjective methods were statistically comparable at both time points whereas, EE assessed by pedometer was significantly lower ($P < 0.017$) compared to self-reported tools. **Conclusion:** Assessment of EE by subjective methods which are based on personal judgment may cause overestimation of PA. In contrast, pedometer readings are likely to underestimate the PA as it only reports kinetics activities. Therefore, a combination of subjective and objective methods is recommended to ameliorate the reliability and validity.

Key words: Activity diary; Energy expenditure; IPAQ; Pedometer

INTRODUCTION

Physical inactivity is a risk factor for the development of type 2 diabetes mellitus (T2DM) in postpartum women with prior gestational diabetes mellitus (GDM). Physical activity (PA) is fundamental for these women, to attenuate the trajectory of GDM to T2DM in their future life.¹ Thus,

periodic assessment is important to understand the level of PA during the 1st year postpartum.²

Since assessing the activity level is a challenge due to variations in intensity, duration and type, energy expenditure (EE) is used as a measure to quantify PA.³ Although the assessment of PA and EE are complex, several subjective

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and objective methods are reported for its accurate determination.⁴ International PA questionnaire (IPAQ), Global PA Questionnaire and activity diary are widely used subjective, self-reported methods of assessing them.⁵ Further, a pedometer or an accelerometer can be used to assess the EE objectively.⁵

Since each type of assessment tool has its advantages and limitations, identifying the most reliable and feasible method of assessing PA based on EE is important in both, clinical practice and research. Although several investigations have been conducted to compare tools, that is, IPAQ short version and pedometer,⁴ IPAQ and ActiGraph⁶ etc., there aren't any reported studies comparing multiple tools within the same population. Further, there is a dearth of evidence regarding a gold standard method to determine the EE focusing on postpartum women with prior GDM.

Aims and objectives

Aim of this study was to compare multiple methods to assess EE with a view to determine the level of PA in postpartum women with prior GDM.

MATERIALS AND METHODS

Study design and setting

This cross-sectional study was a part of a large community-based study carried out to assess the effectiveness of a life style intervention in postpartum women with a history of GDM between August 2016 and July 2019. PA data were obtained from a sub-sample of 50 postpartum mothers with a history of GDM recruited to the main study, selected purposively to ensure a homogenous sample.

Participants were recruited from three selected districts of Sri Lanka, Colombo, Gampaha, and Galle. These districts were selected to enable comparison of findings, as most of the previous Sri Lankan studies on GDM women had been conducted in those districts.⁷⁻⁹

Study participants

Inclusion and exclusion criteria

Women with a history of GDM diagnosed by an Obstetrician based on criteria laid down by International association of diabetes and pregnancy study group (2010)¹⁰ and had delivered a singleton infant were recruited to the study. Women with either a history of GDM in a previous pregnancy or having any other chronic illness were excluded from the study.

Informed written consent was obtained from all participants before data collection. Ethical clearance was obtained from the Ethics Review Committee, University of Sri Jayewardenepura, Sri Lanka.

Data collection

Socio-demographic data

Socio-demographic data including age, ethnicity, education level, marital status, number of Children, and household income were collected using a self-developed and pretested questionnaire. EE during PA was measured using IPAQ, activity diary, and pedometer.

Determining EE using the IPAQ (short version)

The IPAQ-SF records the last 7-day recall for four intensity levels of PA which is vigorous-intensity and moderate-intensity activity, walking, and sitting.¹¹ It is recommended to specify it according to the population and the culture¹² to receive maximum benefits. Therefore, a few responses in the original IPAQ questionnaire were replaced with new responses considering the activities specific for the Sri Lankans. The English version was translated to Sinhala and back translated to English to minimize interpretation errors. Sinhala version was pre-tested among 10 women with a history of GDM attending a maternal and child health clinic in a location away from the study setting to prevent data contamination. PA of women in the past 1 week was assessed by the IPAQ (short version) at 6- and 12-month time points. The women were instructed to write all the activities with the duration separately in a logbook for 1 week before the interview, and the logbook data were compared with IPAQ data to mitigate subject bias. Data were cleaned by removing activities which lasted for <10 min.¹³ The PA levels and intensities were calculated in MET-minutes/week taking into account, the IPAQ scoring protocol, 2005 revision.¹³ MET values assigned for walking, moderate intensity activities and vigorous intensity activities were 3.3, 4.0, and 8.0 METS, respectively.¹³

After calculating the MET minutes/week, the EE at 6- and 12-month time points were determined using the following equation.¹³

$$EE(kcal) = \frac{MET\ minutes\ per\ week \times (body\ weight\ in\ kg)}{60\ kg}$$

Determining EE using the activity diary

At the outset, women were educated on accurate data recording in activity diaries. Clear instructions were given to record all the activities carried out with the durations, from the time of waking up until bed time at night, consecutively for 7 days each month, for a period of 1 year. Transformation of PA data in activity diaries to MET-minutes/week was based on the IPAQ scoring protocol. Evidence from previous literature was used when dealing with activities that are not specified in IPAQ scoring protocol.¹⁴

Women were educated on how to engage in day-to-day activities efficiently to earn MET values (i.e., performing activities continuously for a minimum of 10 min). The mean MET-minutes/week for the 6- and 12-month time points was determined by averaging the monthly MET-minutes/week in the first 6 and the second 6 months, respectively. The mean values of the two 6 months' time periods were taken instead of single values to accommodate variations in activities during the study period. The EE at 6 and 12 months were calculated by the same equation used for the conversions in IPAQ.

Determining EE using the pedometer

Clear instructions were given to women to record their step counts and caloric values displayed in the pedometer (Rossmax PA 320 with an accuracy of $\pm 5\%$ vibration testing machine)¹⁵ monthly for 7 days a month for a duration of 12 months on the same days of the month that they were recording the physical activities in the activity diary. Women were also educated on the use of the pedometer and supervised the procedure till they were confident. The women were instructed to wear the pedometer from the time they wake-up on the days that they get the recordings until bedtime, except during sleeping and having a shower. Reliability of data was ensured by cross checking the recorded EE with the step count. EE at 6- and 12-month time points was obtained by calculating the average of the weekly EE in the first 6 and the second 6 months, respectively.

Monthly home visits and telephone follow-up once in 2 weeks were carried out to ensure the accuracy of PA data using the IPAQ, the activity diary and the pedometer, and to motivate women to perform regular PA.

Statistical analysis

SPSS 25 software was used to analyze the data. Descriptive statistics were used for describing the socio-demographic characteristics of the study participants. Bland-Altman plots test was used to show the level of agreement between IPAQ and the other two tools at 6 and 12 months. As there was no gold standard technique reported for the assessment of PA, the cross culturally validated, IPAQ short version was considered in this study as the reference.¹⁵ Since the EE was not normally distributed in this study, Friedman rank test was performed to compare the EE s obtained by the three tools at relevant time points.¹⁶ When significant differences were identified, post hoc analysis was used to locate the differences. Wilcoxon signed-rank tests on different combinations of related groups were done separately. Following Bonferroni adjustment in preventing

statistical errors, the new significance level was considered as <0.017 .

RESULTS

Socio-demographic characteristics of the study sample

Mean age \pm SD of the study participants was 33.02 ± 5.13 years and all women were educated at least up to Ordinary level; hence, we assumed that the literacy level of all subjects in this study was comparable to each other and also adequate to understand, follow instructions and record data accurately (Table 1).

Bland-Altman plots test

An agreement was observed amongst all pairs obtained using the 3 tools (IPAQ and activity diary, IPAQ and pedometer at 6 and 12 month time points). However, according to Bland-Altman plot results, the highest mean difference was observed between IPAQ and pedometer at 12 months (mean difference was 75.9). This observation indicates an under estimation of pedometer values at 12 months (Figure 1).

Friedman test

There was a statistically significant difference between the median EE assessed by IPAQ and activity diary at 6 months ($\chi^2 [2] = 28.73, P<0.003$) and at 12 months ($\chi^2 [2] = 32.170, P<0.003$). The results of the post hoc analysis showed no significant differences between the EE obtained from the IPAQ and activity diary at both time points studied (6 months, $Z=-1.21, P=0.23$; 12 months, $Z=-6.58, P=0.51$). In contrast, the EE calculated by

Table 1: The distribution of the socio-demographic characteristics of the participants (n=50)

Characteristics	Number
Family income (LKR)	
Below Rs. 50000.00	41 (82%)
Rs. 50000.00 or more	9 (18%)
Education	
Up to GCE O/L	42 (84%)
GCE A/L and above	8 (16%)
Profession	
Professionals	8 (16%)
Other workers	14 (28%)
Housewives	28 (56%)
Number of children	
Two or less	37 (74%)
More than two	13 (26%)
Number of family members	
Below 5	22 (44%)
5 or more	28 (56%)
Ethnicity	
Sinhalese	50 (100%)

GCE O/L: General certificate of examination ordinary level, GCE/A/L: General certificate of examination advanced level

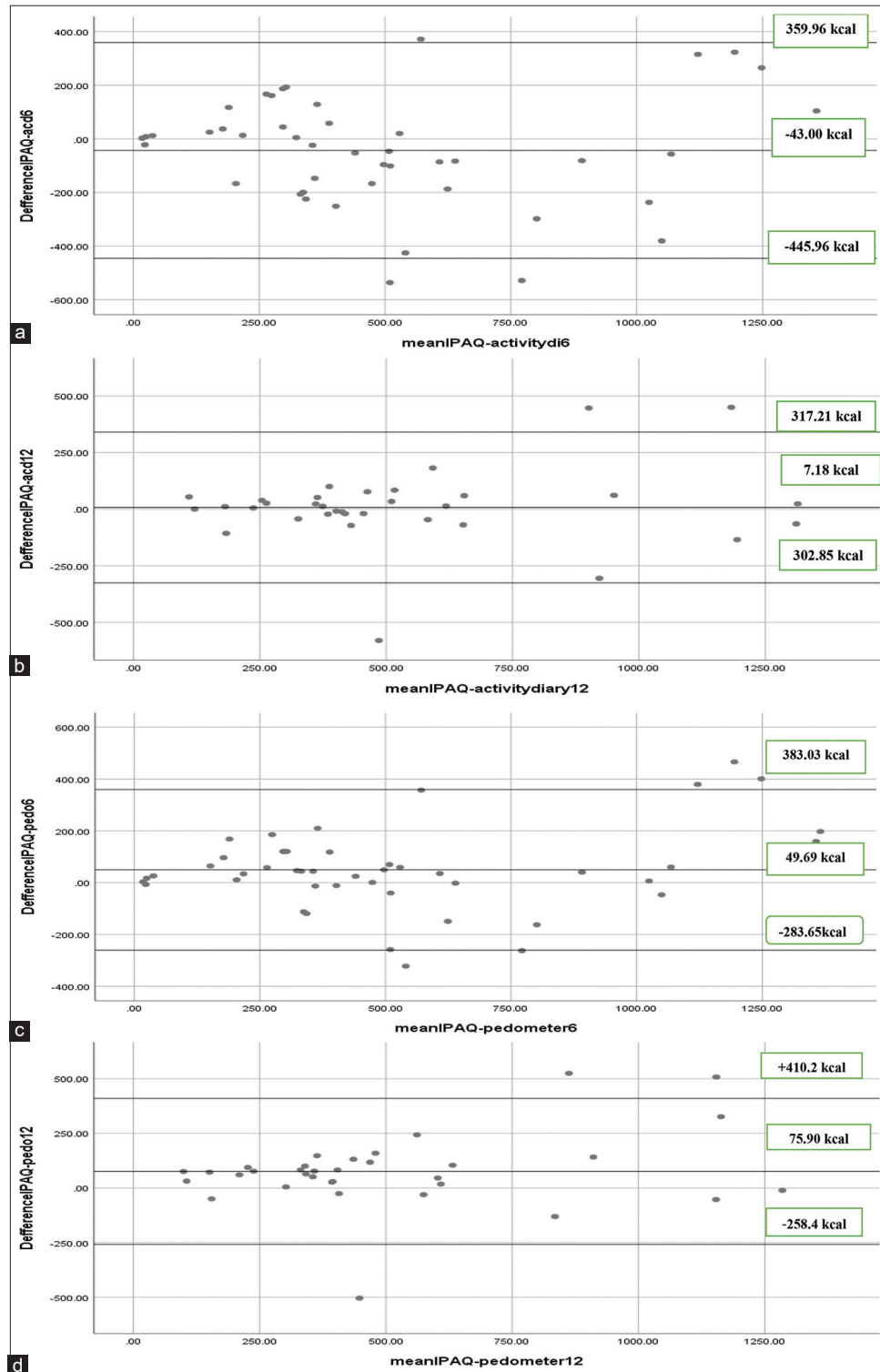


Figure 1: Bland-Altman plots. Agreement between IPAQ and activity diary at 6 months (a), IPAQ and activity diary at 12 months (b), IPAQ and pedometer at 6 months (c), IPAQ and pedometer at 12 months (d). IPAQ: International physical activity questionnaire, acd: activity diary, ped: Pedometer, kcal: Kilocalorie

pedometer readings were significantly lower compared to those determined by IPAQ (6 months, $Z=-2.606$, $P=0.009$; 12 months, $Z=-3.59$, $P<0.001$) and activity diary (6 months, $Z=-6.46$, $P<0.001$; 12 months, $Z=-5.086$, $P<0.001$) at both 6 and 12 months (Table 2).

DISCUSSION

Assessing EE is crucial in evaluating PA in postpartum women with prior GDM. The present study compared the EE measured by 3 tools namely IPAQ, activity diary

Table 2: Comparison of energy expenditure (median) assessed by the three methods at 6 and at 12 months

Time point	IPAQ Median (IQR)	Activity diary Median (IQR)	Pedometer Median (IQR)	P value*
6 months (Kcal/day)	407.45 (395.92)	460.93 (606.31)	370.00 (505.00)	0.000
12 months (Kcal/day)	423.12 (385.93)	447.08 (341.84)	380.00 (310.00)	0.000

IQR: Inter-quartile range, *Friedman test

and the pedometer in postpartum women with a history of GDM at 6 months and at 12 months.

The Bland-Altman test demonstrated an agreement between mean differences of each pair implying the suitability of all instruments in assessing EE. However, a large positive mean difference was observed between the IPAQ and the pedometer at both time points studied which may be due to underestimation of PA by pedometer.

Consistency of the EE obtained by IPAQ (short version) and activity diary at 6 and 12 months imply that these subjective methods are likely to capture the EE in a similar manner. The IPAQ is a cross culturally validated tool¹⁵ which is used as a standardized self-reported measure of habitual PA of populations of different countries.¹⁷ IPAQ is considered suitable for cohort studies such as ours since the response rate is higher compared to other methods.⁴ Activity diary is a cost effective, user friendly tool which assesses the psychometric properties of PA.¹⁸ In assessing PA level using an activity diary, the subjects are given the responsibility of documenting all activities in a day, along with the duration. Therefore, it is also a popular method used by previous investigators even in postpartum mothers, especially to assure the adherence of tailored lifestyle intervention programmes among study groups.^{17,19,20} It is reported that a wide variety of activities including nearly all household activities which are performed for more than 10 min¹² can be assessed using both IPAQ and activity diary. Further, these tools are frequently used due to their low cost, low participant burden and high acceptance.²¹ Despite the advantages these subjective tools possess, there are inherent limitations in terms of reliability and validity. Since these methods rely on self-reported estimates, the integrity and the recalling ability of the study participants may not reflect the actual level of EE. Frequent overestimation of the activity level is considered as a limitation of these tools.^{5,18}

In contrast, assessment of EE by a motion sensor such as a pedometer which is a portable electronic device that estimates the step count, calories consumed, walking time,

distance and speed is advantageous since activities are measured objectively. It records movements during regular gait cycles and designed to measure walking behaviors.¹⁸ Previous studies have reported that the pedometer is a good proxy to PA because it does not rely on self-recall of PA or subjective assessment of exercise intensity, in contrast to PA questionnaires or diaries.⁴ The lower EEs shown in the pedometer values of the current study may be attributed to either underestimation of PA by pedometer or overestimation of the same by subjective methods.

Consistently, a recent community-based intervention study carried out among overweight and obese women in Malaysia demonstrated higher PA levels when IPAQ-Short version was used, compared to direct measurement by pedometer.⁴ The pedometer is not capable of capturing some kinetic activities that incorporate mainly upper body movement such as washing clothes, digging and drawing water leading to underestimation of PA.²¹⁻²³ At the slowest walking speed (54 m/min), most pedometers underestimate steps.¹⁸ Over estimation of PA occurs with IPAQ when sedentary or light activities are classified as moderate or vigorous during scoring.^{21,24} Further, over reporting is likely to be a problem of self-reported tools especially following a lifestyle intervention, because participants have a tendency to give socially desirable responses as they are aware of the advantages of the intervention.²⁵

There are several strengths and limitations in this study. The response rate for IPAQ-short version, activity diary and pedometer were good. A previous study has reported that one of the barriers in using the pedometer was lack of motivation and awareness of participants.²⁶ To overcome this barrier, the participants in the present study were thoroughly trained on the use of the pedometer and followed them up closely.

Limitations of the study

However, this study had a limited number of selected postpartum women. Postpartum women are a unique group in society and their daily routine differs to some extent from the general population. Hence, a similar study including a larger sample is warranted to enhance the generalization of the findings.

CONCLUSION

Therefore, based on the results of the present study, it is recommended to use a self-reported tool in combination with an objective tool like pedometer to ensure accuracy of data in assessing PA based on EE in postpartum women with prior GDM.

Findings of this study will be useful in future studies to assess EE in postpartum women.

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TDS- Conceptualization and design of the study, preparation of first draft of the manuscript; statistical analysis and interpreted the results; reviewed the literature and manuscript preparation; **SW-** Conceptualization, coordination, revision of the manuscript; **CJW-** Statistical analysis and interpretation, manuscript preparation; **PH-** Review of the literature and manuscript preparation

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