The Barriers to Physical Activity in Type 1 Diabetes (BAPAD-1) scale: Predictive validity and reliability

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Abstract

Aim. – Perceived barriers are one determinant of physical activity. Depending on the study population, these barriers can vary. The aim of this study was to assess the reliability and predictive validity of the ‘Barriers to Physical Activity in Type 1 Diabetes’ (BAPAD-1) scale, developed by Dubé et al.

Methods. – A total of 77 adults (48% women; age: 43.5 ± 10.4 years; body mass index: 25.2 ± 4.3 kg/m²; HbA1c: 7.6 ± 1.3%) with type 1 diabetes completed the questionnaire and an evaluation of their physical activity using an accelerometer (8.4 ± 1.2 days) and cardiorespiratory fitness assessment (VO2 peak). To evaluate the temporal stability of the questionnaire, a subgroup of 17 participants answered the BAPAD-1 scale on both visits required by the protocol (10 ± 4 days).

Results. – The BAPAD-1 scale showed good internal validity with an inter-items correlation coefficient (Cronbach’s correlation) of 0.85. The intraclass correlation coefficient for the two times the scales were completed was 0.80. The BAPAD-1 score was negatively correlated with both physical activity energy expenditure (r = −0.25; P = 0.03) and VO2 peak adjusted for gender and age (r = −0.27; P = 0.02).

Conclusion. – The BAPAD-1 scale is a reliable and valid tool for assessing salient barriers to physical activity. In future, this scale could be used to describe the factors accounting for physical activity, and for planning interventions aimed at promoting physical activity among adults with type 1 diabetes.

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Keywords: Type 1 diabetes; Reliability; Validity; Barriers; Physical activity

Résumé

Validité et fiabilité d’un questionnaire sur la perception des barrières vis-à-vis de l’activité physique chez des diabétiques de type 1 (BAPAD-1).

Objectif. – La perception de barrières est un déterminant de la pratique de l’activité physique. Selon la population étudiée, ces barrières varient. L’objectif de cette étude était d’évaluer la fiabilité et la validité d’un questionnaire, développé par Dubé et al., sur les barrières vis-à-vis de l’activité physique chez diabétiques de type 1.

Méthodes. – Soixante-quatorze adultes atteints de diabète de type 1 (48% de femmes ; 43.5 ± 10.4 ans ; IMC moyen 25.2 ± 4.3 kg/m² ; HbA1c 7.6 ± 1.3 %) ont répondu au questionnaire et réalisé une évaluation de leur pratique d’activité physique. La pratique d’activité physique a été évaluée au moyen d’un accéléromètre (8,4 ± 1,2 jours) et d’une mesure de la condition cardiorespiratoire (VO2 peak). Pour évaluer la reproductibilité du questionnaire, un sous-groupe de 17 participants a répondu au questionnaire lors des 2 visites de l’étude (10 ± 4 jours).
1. Introduction

Physical inactivity is a major public-health concern. Even though considerable evidence shows the benefits of regular physical activity (PA) [1], most programmes promoting PA have failed to significantly change the population’s behaviour [2]. To develop efficient interventions improving PA practice, understanding the determinants of PA behaviour, such as perception of self-efficacy, motivators and barriers, is an essential step [3]. The literature on determinants of PA practice among adults demonstrates that these determinants may vary according to age, gender, presence of overweight or obesity and co-morbidities [4]. As such, barriers that are highly related to PA behaviour [5] may differ according to specific group characteristics. Therefore, specific instruments to evaluate perceived barriers are needed [6]. Type 1 diabetes (T1D) is a chronic disease characterized by pancreatic inability to secrete sufficient insulin for blood glucose regulation [7]. As a consequence, patients need multiple daily insulin injections (MDI) or continuous subcutaneous insulin infusion (CSII) to control their glycaemia. As PA greatly influences blood glucose levels [8], modifications in food consumption or insulin delivery are needed in those who exercise to prevent hypo- or hyperglycaemia [9,10]. For this reason, there may be specific barriers to PA among adults with T1D, although the research published on perceived barriers to PA among adults with T1D is limited [11–13].

There are various ways to evaluate perceived barriers, such as through interviews [14,15] and structured or semi-structured questionnaires [16]. In a research context, the main advantage of questionnaires over interviews is that they allow the collection of information from a larger number of people; they are also relatively inexpensive and more reliable, as there are no interviewer effects. In addition, closed-ended questions (yes/no or scales) are more readily evaluated and analyzed than open-ended ones (short answers). Accordingly, a specific questionnaire—the BAPAD-1 scale, an 11-item Likert-type self-reported assessment—was developed by Dubé et al. [13] to assess the perceived barriers to regular PA practice among adults with T1D.

Assessing the psychometric properties of measures such as questionnaires enables researchers and practitioners to compare intervention effects. There are different ways to evaluate a questionnaire in terms of its reliability and its validity. Reliability refers to the consistency or repeatability of a measure [17], while validity is defined as the degree to which the score measures what it was designed to measure [17]. This can be further broken down into construct, concurrent and predictive validity. Predictive validity refers to the extent to which future events are in line with the predictions of the test [18]. An unreliable instrument may produce results that are subject to high variability or measurement error. In the BAPAD-1 scale, if the scale measures important barriers to PA, then one way to test the predictive validity of the questionnaire is to measure PA practice. The more severe the patients’ perceived barriers, the more inactive they should be. Thus, the objective was to test the BAPAD-1 scale’s predictive validity by objectively evaluating PA practice as well as its reliability in an independent population of adults with T1D. The reproducibility of the questionnaire was also evaluated in a subgroup of patients.

2. Materials and methods

2.1. Study design

The two-visit protocol was designed to evaluate the validity and reliability of the BAPAD-1 scale. Inclusion criteria were: duration of T1D for more than 6 months; age over 18 years; and capability of performing an ergocycling test. The diagnosis of T1D was confirmed by the patient’s medical file and history of ketoacidosis. Patients were first approached when attending their regular appointment with their endocrinologist. A total of 82 patients were recruited, and the barriers to PA of 62 of these participants have been described elsewhere [12].

After giving their written informed consent to participate, the patients completed a questionnaire and received an accelerometer for PA assessment. The questionnaire included sociodemographic and diabetes management sections, and the BAPAD-1 scale. To be included in the data analyses, participants had to wear the accelerometer 85% of the time for at least 6 days so that the data would represent both days at work and days off [19]. Seventy-seven patients met these criteria. As the accelerometer was not waterproof, patients were instructed to remove it for water activities such as swimming, showering or bathing. Body weight and height were measured in light clothing and shoeless. Body mass index (BMI) was calculated by dividing body weight (kg) by the square of the height (m²). The most recent value of glycated haemoglobin (HbA1c; not exceeding 3 months from participation in the protocol) was obtained from the patient’s medical chart. Approximately 10 days after the first visit, when returning the accelerometer, participants performed a
cardiorespiratory fitness test on an ergocycle (VO₂ peak). A subgroup of patients (n = 17) completed the BAPAD-1 scale during both visits to evaluate the test–retest reliability of the scale. The project was approved by the ethics and research committees of the Université de Montréal Hospital Center and the Montreal Institute for Clinical Research.

2.2. BAPAD-1 scale

The BAPAD-1 scale was developed through multiple steps [13]. First, the authors elicited salient barriers to PA with an open-ended question addressed to 36 adults with T1D. Based on the response analysis, they developed a 12-item BAPAD-1 scale. The questionnaire was revised by two experts to confirm its relevance and representativeness, then tested and retested 2 weeks later in a group of 74 T1D adults. Participants were asked to rate, on a 7-point Likert-type scale, the likelihood that each of the items would keep them from practising regular PA during the next 6 months (with 1 = extremely unlikely and 7 = extremely likely). One of the items was rejected after the reliability analysis, thus leaving an 11-item scale [13].

2.3. Accelerometer

The SenseWear Armband (SWA) Pro 3 (HealthWear Bodymedia, Pittsburgh, PA, USA) is a motion sensor worn on the back of the upper right arm over the triceps muscle. It measures heat flux, galvanic skin response, skin temperature and near-body temperature, and includes a two-axis accelerometer. These data and several physical characteristics, including gender, age, height, weight and smoking status, are then used to estimate, in part, total energy expenditure, PA energy expenditure, PA level (PAL) and number of steps taken on a daily basis. PA energy expenditure represents every calorie expended at more than three times the resting energy expenditure (> 3 METS, or metabolic equivalents of task), which is classified as moderate PA [20]. PAL is calculated by dividing total energy expenditure by estimated resting energy expenditure [20]. The SWA is a well-validated accelerometer. Its validity has been assessed twice against doubly labelled water, the gold-standard method for evaluating total energy expenditure [21,22], and its reproducibility has been established for a wide range of activities [23]. The use of accelerometers allows an objective observation of PA practice compared with questionnaires [24,25].

2.4. Cardiorespiratory fitness

Subjects performed a graded exercise test on an Ergoline 900 ergocycle (Bitz, Germany) until voluntary exhaustion. During the test, power output was increased by 25 W every 3 min. The highest oxygen consumption obtained during the protocol was considered the VO₂ peak (mL·kg⁻¹·min⁻¹). Expiration gas samples were analyzed during the exercise protocol using a Medisoft Ergocard, software version 6 (Dinant, Belgium), cardiopulmonary exercise test station. A test–retest reliability trial (n = 19) for VO₂ peak performed in our laboratory showed an intraclass correlation coefficient (ICC) of 0.96.

2.5. Data analysis

Data were analyzed by Statistical Package for Social Sciences version 17.0 software (SPSS, Inc., Chicago, IL, USA). All study variables were examined for normality of distribution prior to analysis. Descriptive statistics (means, standard deviations, frequencies, range) were calculated for the sociodemographic and study variables. Student’s t and Chi² tests were used to compare descriptive statistics for gender and healthy PA behaviour. Internal reliability of the BAPAD-1 scale was determined by Cronbach’s coefficient alpha test. The test–retest reproducibility of the BAPAD-1 score was determined by comparing the results of the two separate occasions that the questionnaire was filled in. The ICC was calculated to measure the reliability of the BAPAD-1 scale, with an ICC > 0.60 considered acceptable. Pearson correlations were used to evaluate the association between the BAPAD-1 score and measures of PA practice. The level of significance was set at a P value < 0.05.

3. Results

The final sample consisted of 77 adults (48% women) with T1D, and their characteristics are presented in Table 1. The mean BAPAD-1 score was 2.4 ± 1.0 (range: 1.0–4.9), which corresponds to a low level of perceived importance for the assessed barriers. Parametric analysis of the BAPAD-1 scale showed a Cronbach alpha coefficient of 0.85, which represents a high degree of interrelatedness among the 11 items. Reliability was determined according to stability of the measure (test–retest), and the ICC was 0.80 (95% CI: 0.44–0.93).

The accelerometer was worn for 8.4 ± 1.2 days and for 96.4 ± 2.7% of the time. Data related to PA practice and cardiorespiratory fitness are presented in Table 2. Mean PA energy expenditure and mean PAL were lower among women than men. To illustrate the prevalence of healthy PA behaviour in this population, a descriptive analysis of the participants who achieved some PA recommendations for healthy benefits is also presented in Table 2. Classification of PA behaviour was based on the PAL estimated by the accelerometer data and the VO₂ peak measured by the graded exercise (healthy VO₂ peak ≥ normative data for age and gender) [20,26]. A PAL ≥ 1.6 was considered healthy PA behaviour. The higher prevalence of healthy PA behaviour among men was not significantly different from that in women. Cardiorespiratory fitness, adjusted for gender and age, and PAL were positively correlated (r = 0.53; P < 0.001).

Fig. 1 shows the negative association between the BAPAD-1 score and PA energy expenditure as evaluated by the SWA. The BAPAD-1 score was also negatively associated with PAL (r = −0.24; P = 0.03) and with cardiorespiratory fitness, as measured by the VO₂ peak (mL·kg⁻¹·min⁻¹; r = −0.27; P = 0.02). Correlation between the VO₂ peak and BAPAD-1 score was adjusted for gender and age. Perceived barriers were not associated with the number of steps taken per day (r = −0.05; P = 0.65).
Table 1
Study participants’ characteristics.

<table>
<thead>
<tr>
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<th>All (n = 77)</th>
<th>Female (n = 37)</th>
<th>Male (n = 40)</th>
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<tr>
<td></td>
<td>Mean ± SD (range)</td>
<td>Mean ± SD (range)</td>
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<tr>
<td><strong>Age (years)</strong></td>
<td>43.5 ± 10.4 (22.5–67.2)</td>
<td>44.0 ± 11.2 (23.7–67.2)</td>
<td>43.0 ± 9.7 (22.5–61.5)</td>
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<tr>
<td><strong>Active smoker (%)</strong></td>
<td>19.5</td>
<td>16.2</td>
<td>22.5</td>
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<tr>
<td><strong>Weight (kg)</strong></td>
<td>73.0 ± 15.1 (38.2–124.7)</td>
<td>64.3 ± 12.4 (38.2–102.0)</td>
<td>81.0 ± 12.8 (61.5–124.7)</td>
</tr>
<tr>
<td><strong>Body mass index (kg/m²)</strong></td>
<td>25.2 ± 4.3 (14.7–41.7)</td>
<td>24.3 ± 4.6 (14.7–40.1)</td>
<td>26.0 ± 3.9 (21.7–41.7)</td>
</tr>
<tr>
<td><strong>Obesity (%)</strong></td>
<td>11.7</td>
<td>8.1</td>
<td>15.0</td>
</tr>
<tr>
<td><strong>Diabetes duration (years)</strong></td>
<td>23.5 ± 12.3 (1.1–55.2)</td>
<td>24.8 ± 14.4 (1.2–55.2)</td>
<td>22.4 ± 9.9 (1.1–43.4)</td>
</tr>
<tr>
<td><strong>Insulin requirement (unit/kg)</strong></td>
<td>0.62 ± 0.21 (0.22–1.48)</td>
<td>0.58 ± 0.23 (0.22–1.48)</td>
<td>0.66 ± 0.19 (0.24–0.99)</td>
</tr>
<tr>
<td><strong>Glycated haemoglobin (%)</strong></td>
<td>7.6 ± 1.3 (5.0–12.0)</td>
<td>7.7 ± 1.6 (5.0–12.0)</td>
<td>7.5 ± 0.9 (5.6–9.0)</td>
</tr>
<tr>
<td><strong>Severe hypoglycaemic episodes per patient-year</strong></td>
<td>0.5 ± 1.6 (0–12)</td>
<td>0.5 ± 1.3 (0–6)</td>
<td>0.6 ± 1.9 (0–12)</td>
</tr>
<tr>
<td><strong>Diabetes treatment (%)</strong></td>
<td>MDI 87.0 (women 78.4, men 95.0)</td>
<td>CSII 13.0 (women 21.6, men 5.0)</td>
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MDI: multiple daily insulin injections; CSII: continuous subcutaneous insulin infusion.

<table>
<thead>
<tr>
<th></th>
<th>All (n = 77)</th>
<th>Women (n = 37)</th>
<th>Men (n = 40)</th>
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<tr>
<td></td>
<td>Mean ± SD (range)</td>
<td>Mean ± SD (range)</td>
<td>Mean ± SD (range)</td>
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<tr>
<td><strong>Total EE (kcal/day)</strong></td>
<td>2854 ± 702 (1830–5008)</td>
<td>2353 ± 323 (1830–3195)</td>
<td>3317 ± 638 (2109–5008)</td>
</tr>
<tr>
<td><strong>PA EE (kcal/day)</strong></td>
<td>990 ± 662 (181–3182)</td>
<td>711 ± 403 (181–1640)</td>
<td>1249 ± 750 (342–3182)</td>
</tr>
<tr>
<td><strong>PAL</strong></td>
<td>1.7 ± 0.4 (1.0–2.7)</td>
<td>1.6 ± 0.3 (1.0–2.3)</td>
<td>1.8 ± 0.4 (1.2–2.7)</td>
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<tr>
<td><strong>Steps per day</strong></td>
<td>9632 ± 3381 (4382–18735)</td>
<td>9059 ± 3312 (4382–17203)</td>
<td>10 161 ± 3398 (5670–18735)</td>
</tr>
<tr>
<td><strong>VO₂ peak (mL·kg⁻¹·min⁻¹)</strong></td>
<td>29.2 ± 9.2 (14.9–56.2)</td>
<td>24.8 ± 6.3 (14.9–42.0)</td>
<td>33.1 ± 9.8 (16.9–56.2)</td>
</tr>
<tr>
<td><strong>Healthy PA behaviour</strong></td>
<td>PAL ≥ 1.6 (%)</td>
<td>58.4</td>
<td>67.5</td>
</tr>
<tr>
<td></td>
<td>Healthy VO₂ peak (%)</td>
<td>43.1</td>
<td>35.3</td>
</tr>
</tbody>
</table>

EE: energy expenditure; PA EE: physical activity energy expenditure; PAL: physical activity level (≥ 1.6 = active).

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The present results confirmed the first reliability analysis of the scale with an identical Cronbach alpha coefficient of 0.85 [13]. The test–retest analysis also showed excellent agreement (ICC > 0.75) between the two separate completions of the scale.

The predictive validity of the BAPAD-1 scale was evaluated by comparing the perceived level of barriers to PA (the BAPAD-1 score) with an objective measure of PA. On average, the present study population had a low level of perceived barriers, which is similar to other populations of adults with T1D [13] as well as other adult populations [27]. Previously, we demonstrated that the BAPAD-1 score was positively associated with HbA1c ($r = 0.20$), and negatively associated with perceived well-being ($r = -0.45$) and social support ($r = -0.20$) [12]. Among adults with T1D, age and gender were not associated with the severity of the perceived barrier [12]. Yet, even with the mean low level of perceived barriers in our present population, a significant association was found with PA energy expenditure as measured by the accelerometer. The perception of barriers explains 6% of the PA energy expenditure. Using the PA energy expenditure as a measure of PA offers the advantage of taking into account the different aspects of PA, such as active transport (walking, cycling) and structured exercise (going to the gym). Furthermore, even if cardiorespiratory fitness is not a direct measure of actual PA practice, it is influenced by genetics, body composition, age, gender and diabetes control, and positively influenced by and correlated with past activities [28], it offers an additional surrogate measure of fitness-related PA habits in adults [29]. The BAPAD-1 score was also significantly associated with cardiorespiratory fitness. Consequently, the perception of barriers was negatively associated with past and present PA, as measured by cardiorespiratory fitness and accelerometer, both of which are related to the risk of coronary heart disease and other health outcomes in a dose–response relationship [30,31]. The BAPAD-1 reveals the perceived barriers related to overall PA behaviour. The non-association between the BAPAD-1 score and number of daily steps was not surprising, as the accelerometer tends to overestimate the number of steps taken per day [32].

Although evaluating the predictive validity of a questionnaire is necessary to address the strength of the instrument, few studies have been done to evaluate this aspect among the tools intended to quantify barriers to PA [33]. Yet, this is an important step to verify if psychosocial concepts are associated with an objective measure of behaviour. Limited research has assessed the predictive validity of questionnaires of barriers to PA, and none specifically for the T1D population. Thus, the present study is the first to address the predictive validity of a scale designed to elicit the major barriers impeding PA practice among adults with T1D.

Indeed, barriers are an important determinant of PA practice [34]. In previous studies, PA was mostly reported through questionnaires on frequency, intensity and durations of PA sessions. Our present results are in line with other studies showing that <10% of PA variance is due to perceived barriers in the general adult population [27]. However, to our knowledge, the present study is the first to show this association with an objective measure of PA in an adult T1D population. The results are interesting as they link an individual perception to an objective measure of behaviour. To explain the higher proportion of PA variance, a questionnaire should not be limited to perception of barriers. An ecological model of health behaviour that includes individual and environmental concepts [35] would explain a larger proportion of PA variance [36]. As for analysis of psychosocial correlates, such as self-efficacy and motivators, it can explain up to 30% of PA variance. However, the aim of the present study was to validate the BAPAD-1 scale, and not to explain a larger proportion of PA variance. The BAPAD-1 scale is not a measure of PA. Eliciting barriers with a valid questionnaire is only one part of the evaluation of PA psychosocial correlates.

The study population was composed of a wide age range (from 22 to 67 years) of adults with long-standing T1D. The prevalence of participants achieving healthy PA behaviour varied from 43 to 58%, depending on the criteria used. Looking at cardiorespiratory fitness, a lower proportion of participants met the normative value, with specific reference to age and gender, for a non-sedentary lifestyle. However, those values were underestimated, as the VO2 peak was assessed on an ergocycle rather than a treadmill [37], which is more similar to general PA. On the other hand, when looking at the PAL based on the 8-day data collected by accelerometer, close to 60% of the sample reached an adequate PAL that could be considered an active lifestyle. On average, the present group of patients was active. As cardiorespiratory fitness is linked to past PA habits in the weeks and months prior to our testing, and also depends on genetic factors, and the type of test and ergometer used, differences between the two measures were anticipated. However, PAL and cardiorespiratory fitness were strongly correlated.

Even with the use of accelerometers to objectively measure PA practice vs questionnaires, which can overestimate PA practice by up to 60% [24], our present population was more active than those of previous studies, in which close to 60% of T1D patients were considered inactive [11,38]. These discrepancies might be related to methods of PA estimation and
selection bias. As already mentioned, approximately two-thirds of the adults who filled in the BAPAD-1 scale in a previous study [12] agreed to participate in the present protocol. Reasons for non-participation were diverse (such as pregnancy, busy schedule, heart condition and failure to make contact). Those who declined to participate in the former study had higher BMIs, poorer perceptions of health status, a tendency towards poor glucose control and less knowledge of insulin pharmacokinetics. Thus, the present study group may not be representative of the general population of adults with T1D. Also, as seen in previous studies, women were more inactive than men [39].

The main strength of the present study was the use of a validated instrument to objectively measure PA. An alternative method to measure PAL would be the combined use of doubly labelled water to determine total energy expenditure and resting metabolic rate using indirect calorimetry. However, even those methods would not preclude the possibility that our subjects’ PA was influenced by the experimental process, and such procedures are also expensive. In addition, the SWA has been validated against doubly labelled water [22].

Our study had several other limitations. The subjects who volunteered to participate in this PA assessment were relatively more active than those in previous reports in the literature [11,38]. By including highly motivated adults, we may have omitted the more inactive population, in whom a stronger association could be hypothesized and, therefore, our study may have underestimated the relationship. Using cardiorespiratory fitness, PA energy expenditure and PAL as measures of PA practice allowed no specific observations as to the association between frequency and intensity of structured PA. Furthermore, participants may have modified their usual PA, thereby introducing a desirability bias. However, to prevent such a bias, participants were asked to wear the motion sensor for at least 1 week. Moreover, due to the study’s cross-sectional design, causality between severity of perceived barriers and PA behaviour cannot be inferred. The severity of the perceived barriers is moderately, but significantly, associated with less PA practice. It is also possible that presenting an active lifestyle masks the perception of barriers.

5. Conclusion

The present study confirms the reliability and validity of the BAPAD-1 scale. This low-cost and easy-to-use scale reveals important barriers in adults with T1D associated with true PA practice. Such validation is essential to ensure that the scale indeed elicits the required information as, compared with interviews, it is difficult to obtain or give additional clarification and information via a questionnaire. In future, this scale could be used to identify some of the factors explaining PA practice and to plan interventions aimed at promoting PA among adults with T1D. However, further evaluation of the BAPAD-1 scale in populations of T1D subjects with wider variations of PA and cardiorespiratory fitness is now required.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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