



Review

Predicting intentions and behaviours in populations with or at-risk of diabetes: A systematic review

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ABSTRACT

Purpose. To systematically review the Theory of Planned Behaviour studies predicting self-care intentions and behaviours in populations with and at-risk of diabetes.

Methods. A systematic review using six electronic databases was conducted in 2013. A standardised protocol was used for appraisal. Studies eligibility included a measure of behaviour for healthy eating, physical activity, glucose monitoring, medication use (ii) the TPB variables (iii) the TPB tested in populations with diabetes or at-risk.

Results. Sixteen studies were appraised for testing the utility of the TPB. Studies included cross-sectional ($n = 7$); prospective ($n = 5$) and randomised control trials ($n = 4$). Intention (18–76%) was the most predictive construct for all behaviours. Explained variance for intentions was similar across cross-sectional (28–76%); prospective (28–73%); and RCT studies (18–63%). RCTs (18–43%) provided slightly stronger evidence for predicting behaviour.

Conclusions. Few studies tested predictability of the TPB in populations with or at-risk of diabetes. This review highlighted differences in the predictive utility of the TPB suggesting that the model is behaviour and population specific. Findings on key determinants of specific behaviours contribute to a better understanding of mechanisms of behaviour change and are useful in designing targeted behavioural interventions for different diabetes populations.

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Introduction

Type 2 diabetes (T2D) is a major public health challenge with increasing prevalence coinciding with changes in environment and lifestyle behaviours (International Diabetes Federation, 2011). Pre-diabetes is a high-risk state for type 2 diabetes. At least, 5–10% of people at risk will progress to diabetes every year (American Diabetes Association, 2013; Tabák et al., 2012). Therefore, assisting people with type 2 diabetes (T2D), pre-diabetes or who are at-risk through lifestyle modification is becoming an increasingly urgent public health agenda (Tabák et al., 2012).

Self-management is the cornerstone to prevention and management of diabetes and requires adoption of healthy lifestyle behaviours (International Diabetes Federation, 2011). It involves the skilful integration of self-care behaviours such as healthy diet, regular exercise, optimum weight control, self-monitoring of blood glucose and medication adjustment into daily routines over long periods (Funnell and Anderson, 2008; NHMRC, 2001). Self-care behaviours are influenced by a number of factors often based on day-to-day decisions that accumulate to form patterns, habits and eventually a lifestyle (American Association of Diabetes Educators, 2009; Wagner, 2011). Evidence suggests that adopting a healthier lifestyle and behaviour modification through education and self-care strategies are effective in managing and preventing long term diabetes complications (Lindström et al., 2006). Despite efforts to reduce the burden of type 2 diabetes, self-management through healthier lifestyle behaviours continue to pose a significant challenge for people with diabetes (Nam et al., 2011).

It is increasingly recognized that the development of effective interventions requires an understanding of the behaviours to be modified for a specific population in a given context (Glanz and Bishop, 2010). Examining determinants which influence self-care behaviours is important for identifying modifiable predictors to explain behaviour change (Fishbein and Ajzen, 2009). In particular, predicting intentions and self-care behaviours to develop models for diabetes self-management interventions are most effective when based on health behaviour theories (Glanz and Bishop, 2010; Godin and Kok, 1996; Michie et al., 2008).

For several decades, researchers have used health behaviour theories in gaining a better understanding of the cognitive mechanisms underlying adoption of health-related behaviours. Amongst these theories, Ajzen's Theory of Planned Behaviour (TPB) is one of the most widely tested health behaviour models. The Theory of Planned Behaviour states that intentions are the most important determinant of people's behaviour. Intentions (I) are determined by attitudes (A), subjective norms (SN) and perceived behavioural control (PBC). Attitudes represent an individual's overall positive or negative evaluation of performing the behaviour. Subjective norms reflect the perceived approval or disapproval from significant others (or referents)

for behavioural performance. Perceived behavioural control (PBC) explains the perceived extent to which a behaviour is under the person's control and influences both intentions and behaviours (Fig. 1) (Ajzen, 2011a; Fishbein and Ajzen, 2011).

In addition, the TPB model identifies specific beliefs (behavioural, normative and control beliefs) referred to as indirect predictors. According to the theory, these beliefs formed by background and demographic factors such as age, education, income, personality traits, past behaviours, social and cultural factors, indirectly influence the TPB determinants and vary across behaviours and different populations (Ajzen, 2011a). Differences in cultural values, social and environmental influences may reflect belief structures of any given population and behaviour (Glanz et al., 2008). A behaviour that is attitudinally driven in one population or culture may be normatively driven in another. Therefore, changing behaviour requires changing underlying salient beliefs (Fishbein and Ajzen, 2011).

To understand why a person holds a given intention and/or engages with behaviour, it is important to first determine the degree to which intentions (or behaviour) are under attitudinal, normative or perceived control. Whilst there have been much support for the predictive efficacy of the TPB across a broad range of health-related behaviours (Armitage and Conner, 2001; Godin and Kok, 1996; Hagger et al., 2002; McEachan et al., 2011), empirical literature investigating explanatory models to predict intentions and behaviour specifically amongst individuals diagnosed with pre-diabetes and diabetes is limited.

Aim and objectives

The primary aim of this systematic review was to investigate the utility of the TPB to explain intentions and behaviours in populations with pre-diabetes and type 2 diabetes (T2D). The objectives were to: (1) identify studies that used the TPB in pre-diabetes (at-risk) and type 2 diabetes populations and (2) explain percentage variance in intention and behaviour for diabetes self-care behaviours including but not limited to healthy eating, physical activity, glucose monitoring, and diabetes-self-care.

Methods

Information sources and search strategy

A standardised protocol was developed and followed for all steps in the review (Fig. 2). A systematic search, with no date restrictions, was undertaken in relevant databases, of any behavioural studies using the TPB relevant to diabetes and pre-diabetes. Self-management was broadly defined as behaviours in pre-diabetes or at-risk and type 2 diabetes populations which included diet or healthy eating, physical activity, taking medication and self-monitoring of blood glucose.

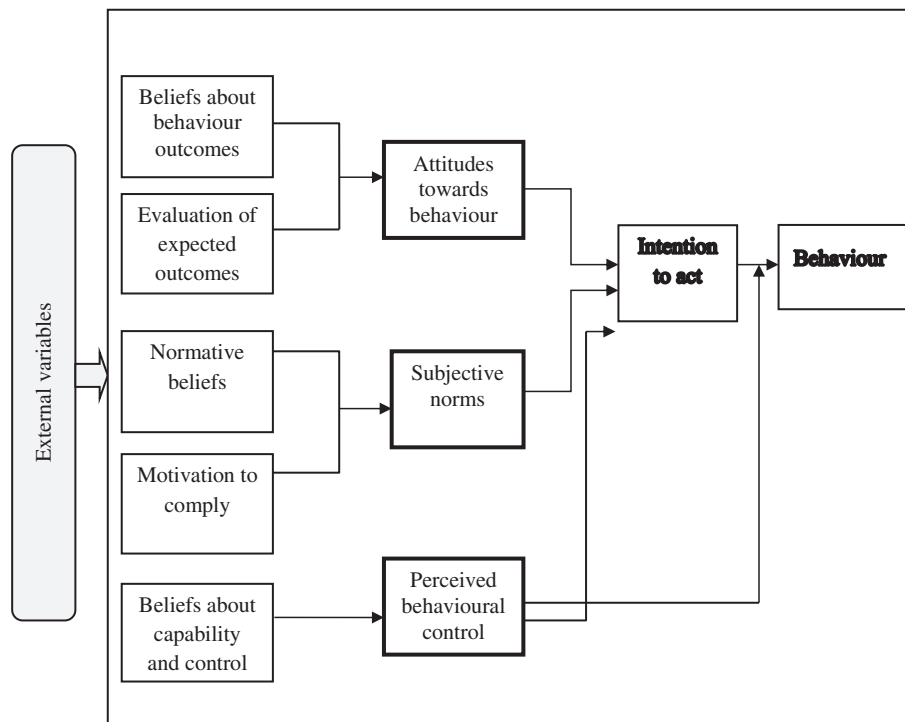


Fig. 1. Theory of Planned Behaviour (Ajzen, 2011a).

Key databases searched included CINAHL, PsycARTICLES, MEDLINE, EMBASE, PsychINFO, PubMed, and ISI Web of Science electronic databases were from start to 2014. Search terms were divided into three groups (i) diabetes (e.g. diab* OR type 2 diabetes) (ii) theory (e.g. Theory of Planned Behaviour OR TPB) and (iii) behaviour (e.g. physical activit* OR exercise*). The behaviour search terms also included a number of dietary, exercise, medication, glucose monitoring terms.

Group 1: ALL Text (TX) and MESH terms: 'diabetes' OR 'Pre-diabetes' OR 'at-risk diabetes' OR 'type 2 diabetes' OR 'type 2 diab*' OR 'T2DM' OR 'metabolic syndrome' OR 'diabetic' OR 'blood glucose' OR 'blood sugar' OR 'HbA1c' OR ('glyce*' OR 'glycem*' OR 'glycaem*') OR 'pre-diabetes' OR 'prediab*' OR 'at-risk of diab*' OR ('diabetes manag*' OR 'diabetes self-manag*' OR 'diabetes self-care').

Group 2: ALL Text (TX) and MESH terms: theory of planned behaviour OR theory of planned behav* OR TPB OR Theory of Reasoned Action' or 'TRA' OR social cognitive theories OR SCT.

Group 3: Mesh terms: (MH 'healthy eat*' or 'diet*') AND (physical activit* or 'exercise*') AND (glucose monitor*) AND (medication adhere* or 'medication*' or 'taking medica*' or 'diabetes tablets' or 'diabetes medication' or 'insulin*' or insulin inject* or non-insulin injection).

Searching

To ensure all studies were included at least one term from each group, the Boolean phrase 'AND' was used between groups and the phrase 'OR' was used within groups. Where possible, the following limits were applied: 'peer-reviewed', 'English', 'human', 'article or review'. Unpublished studies and non-English studies were not considered for this review. For an example of the full electronic search strategy, see Appendix: A1.

The first step was used to identify articles related to the target population. The ALL Text (TX) and MESH terms were used to identify target populations with diabetes or pre-diabetes or at-risk of diabetes. The

next step was used to identify studies that applied the specified theory using free-text searches 'Theory of Planned Behaviour' or TPB or 'Theory of Reasoned Action' or TRA or 'Social Cognitive Theories'. A broad range of terms were incorporated in step three to identify specific diabetes related behaviours in target populations. The final step (step 4) was used to identify relevant articles. Table 1 outlines the number of articles retrieved from the databases searches.

Study selection criteria

Studies which tested the TPB to predict behaviours in type 2 diabetes or pre-diabetes (or at-risk) populations were included in this review. Both experimental and epidemiological study designs including randomised controlled trials (RCT), prospective and cross-sectional studies were considered for this review. Studies were included if they were (i) published in English; (ii) reported TPB variables (attitude, subjective norm, perceived control, intention and behaviour); (iii) explicitly tested the TPB variables in target populations with diabetes or pre-diabetes or (at-risk); and (iv) studies not reporting behaviour outcomes but included the TPB variables.

Exclusion criteria were as follows: (1) not a primary study (i.e. reviews including systematic or meta-analyses, study protocol or letter); (2) participants did not meet the inclusion criteria or reported multiple chronic illness without specified diabetes sub-population; (3) duplicate publications or sub-studies of included research; (4) studies where full text were not available; (5) studies or interventions where the TPB predictive variables/outcomes not reported; (6) development of TPB scales that did not report predicted TPB outcomes; (7) qualitative research-eliciting TPB beliefs; and (8) did not measure behaviour or intention as a study outcome. Conferences abstracts, dissertations and non-peer published articles were not included.

Study selection

Studies were assessed for eligibility by reviewing the title and abstracts of each record for relevance to the review objective. Studies were eliminated if articles were reviews or meta-analyses, not based

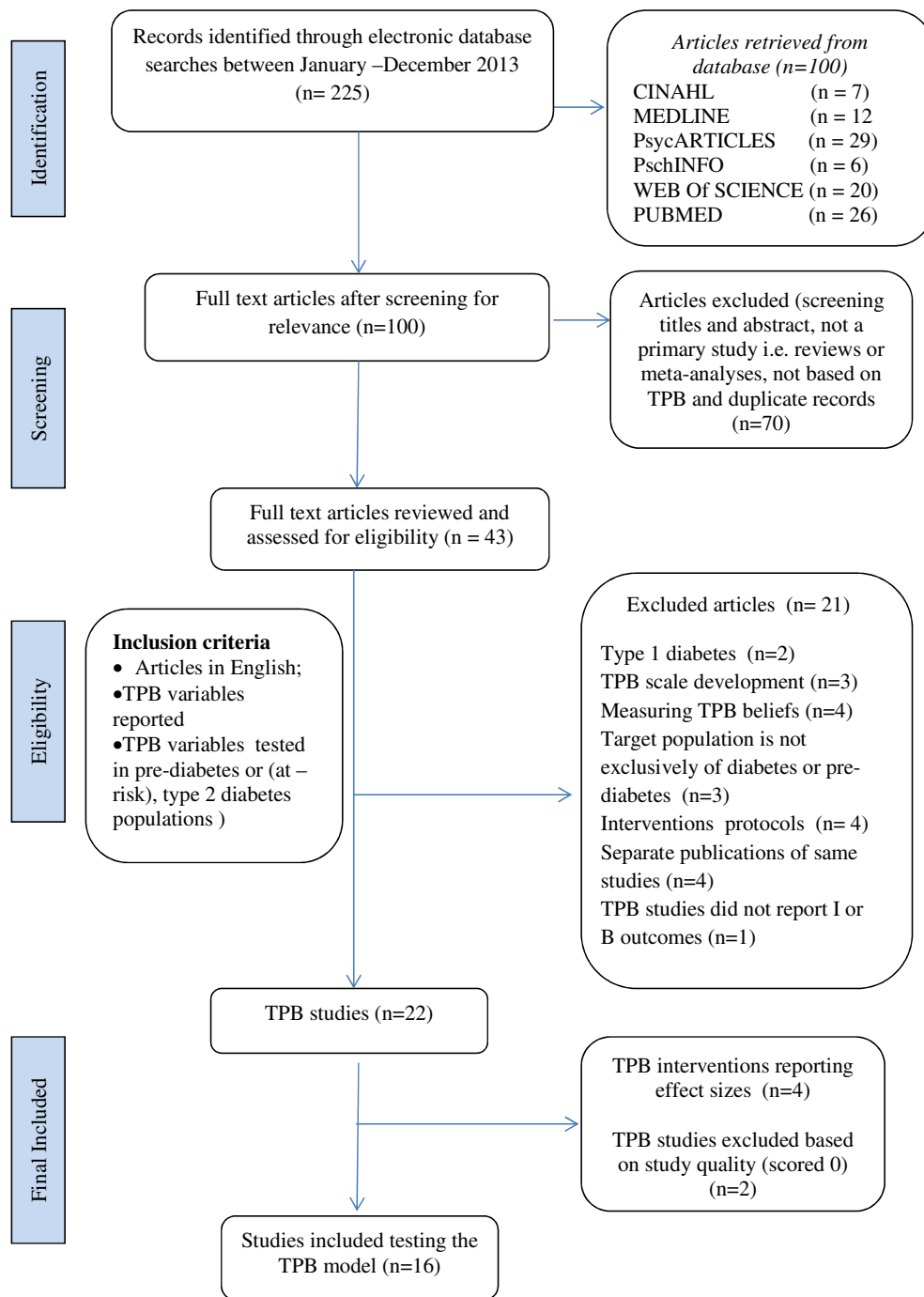


Fig. 2. Flow chart of study selection and screening process.

on relevant tested theory and population. Duplicate publications across searches were also removed. Following this process, full copies of studies were retrieved and further assessed for eligibility. The reference lists of retrieved studies in the search were also cross-referenced for additional articles.

Methods for data extraction and assessing data quality

Specific study characteristics were identified and extracted by the lead author using a standardised form. These characteristics included the (1) study population (T2D, pre-diabetes or at-risk), (2) theory tested, (3) method of assessment (4) TPB constructs assessed (5) association path co-efficient and variance (%) explained. Key characteristics of the

identified studies were also extracted including: the country where the study was conducted, year of publication, size of study population and study design. A second author checked all decisions and any differences were resolved by a third author, if necessary.

Assessment of individual studies

The criteria for assessing study quality/ risk of bias was adapted from recommendations outlined in the STROBE statement (von Elm et al., 2007); the Consolidated Standards of Reporting Trials (CONSORT) statement (Moher et al., 2010) and reviews with similar methods (Plotnikoff et al., 2013a; Young et al., 2014). The criteria included five questions: (1) Did the study describe participant eligibility criteria? (2) Were the

Table 1
Studies testing the Theory of Planned Behaviour in populations with type 2 diabetes or pre-diabetes (n = 16).

Number of References Studies		Target behaviours
3	Gucciardi et al. (2007) [RCT] White et al. (2010) [PS] Chapman et al. (1995) [CS]	Healthy eating or dietary (HE)
8	Boudreau and Godin (2009) [CS] Boudreau and Godin (2014) [RCT] Davies et al. (2010) [PS] Plotnikoff et al. (2008, 2011) (same studies) ^a [PS] Plotnikoff et al. (2014a) [RCT] (ADAPT) Plotnikoff et al. (2010a, 2014b) (same studies ADAPT) ^a [PS] Plotnikoff et al. (2010b) [PS] Hardeman et al. (2011a,b) (same studies) ^a [PS]	Physical activity (PA)
2	Blue (2007) [CS] Lakerveld et al. (2011) [CS]	PA & HE
1	Costa et al. (2012) [CS]	Self-monitoring of blood glucose
2	Gatt and Sammut (2008) [CS] Didarloo et al. (2011, 2012, 2014) (same studies) ^a [CS]	Diabetes self-care ^a
4	White et al. (2012) (PA and HE) [RCT] Jennings et al. (2014) (PA) [RCT] Plotnikoff et al. (2013b) (PA-ADAPT) [RCT] Boudreau et al. (2011)	TPB Intervention ^b

The studies in *italics* are reported in this review.

[CS] – cross-sectional; [PS] – prospective study; [RCT] – randomised control trial.

^a Authors reporting findings of same study based on sample size, study design and target population.

^b The TBP interventions excluded from the review that did not report I or B outcomes only effect sizes.

participants randomly selected and; was the process of randomisation described? (3) Did the TPB measures have acceptable reliability (a score was assigned if the study reported both internal consistency (Cronbach's alpha >0.60) and test–retest reliability ICC > 0.7 or Pearson's correlation > 0.8)? (4) Did the study report the sources and details regarding reliability of the behaviour assessment? and (5) Did the study report a power calculation and was it specifically stated as being adequately powered? Each of these criteria was assigned a value '0' (absent or inadequately described) or '1' (explicitly described and present). Studies that scored 0–2 were regarded as having a high risk of bias, studies that scored 3–4 were classified as having moderate risk of bias and those that scored 5 or classified as low risk of bias studies (see Appendix: Table A1).

Synthesis

Whilst meta-analysis was considered, a narrative analysis of the results was chosen because of high heterogeneity of the included studies in this review (Grade Working Group, 2004). The review included two sub-populations (pre-diabetes and T2D); different behaviours examined; study designs varied across the studies (cross-sectional, prospective, RCT); sample sizes varied between studies; heterogeneity of study methods and measures; and primary outcome or measures for some studies were not reported.

Results

Literature search

The literature search yielded a total of 225 potentially relevant articles; 100 abstracts and full text articles were retrieved after screening for relevance (Fig. 2). Seventy articles were deemed ineligible and removed as they were reviews or meta-analyses or were studies that

did not mention TPB. Full articles of the remaining 43 papers were examined in detail that met the inclusion criteria. A further 21 articles were excluded for reasons indicated in Fig. 2. A total of 22 studies met the inclusion criteria. Eighteen studies tested the TPB model (Blue, 2007; Boudreau and Godin, 2009, 2014; Chapman et al., 1995; Costa et al., 2012; Davies, 2008; Davies et al., 2010) (Didarloo et al., 2012; Gatt and Sammut, 2008; Gucciardi et al., 2007; Hardeman et al., 2011b; Lakerveld et al., 2011; Plotnikoff et al., 2008, 2010b, 2014a,b; White et al., 2007, 2010). Two studies were further excluded for low methodological quality (scored 0) (Davies, 2008; White et al., 2007). Four interventions studies were also excluded because the TPB predictive measures were not reported (Boudreau et al., 2011; Jennings et al., 2014; Plotnikoff et al., 2013b; White et al., 2012) (Table 1). A final number of 16 TPB studies were included in the review.

Study characteristics

Table 2 outlines the characteristics of the sample, the TPB variables, measure outcomes, results and study quality. This review identified seven cross-sectional studies; six prospective and three randomised control trials (RCT). The reported behaviours included healthy eating (HE) or dietary (n = 3); physical activity (PA) (n = 8), combined healthy eating and physical activity (n = 2), self-monitoring of blood glucose (SMBG) and diabetes self-care (n = 2).

Most studies included populations with T2D and three included at-risk populations (Blue, 2007; Hardeman et al., 2011b; Lakerveld et al., 2011). One study examined elderly male (Lakerveld et al., 2011) and two studies had female populations (Didarloo et al., 2012; Plotnikoff et al., 2014a). Three studies did not measure behavioural outcomes (Blue, 2007; Boudreau and Godin, 2009; Lakerveld et al., 2011).

A majority of studies recruited participants from health or diabetes clinics and community health centres (Chapman et al., 1995; Didarloo et al., 2012; Gatt and Sammut, 2008; White et al., 2010); whilst others used recruitment strategies including posters, flyers, public advertisements, mailing lists, referrals from health professionals (Blue, 2007; Costa et al., 2012), diabetes registers (Gatt and Sammut, 2008; Hardeman et al., 2011b) and a health insurance database (Boudreau and Godin, 2009). One study recruited participants from an existing randomised clinical trial (Lakerveld et al., 2011).

Randomised control trials

Three RCTs included in this review originated from Canada (Boudreau and Godin, 2014; Gucciardi et al., 2007; Plotnikoff et al., 2014a). Two studies examined PA behaviour (Boudreau and Godin, 2014; Plotnikoff et al., 2014a) whereas one looked at nutrition adherence and dietary management (Gucciardi et al., 2007).

Two studies looked at adult populations with T2D and included both genders (Boudreau and Godin, 2014; Gucciardi et al., 2007). One study included women with T2D (n = 93) (Plotnikoff et al., 2014a). Two studies did not provide sufficient information about recruitment strategies (Boudreau and Godin, 2014; Plotnikoff et al., 2014a), though related papers provided more detail. One study recruited participants through a hospital diabetes education centre (Gucciardi et al., 2007).

The design of the interventions was either randomised control trials (Gucciardi et al., 2007; Plotnikoff et al., 2014a) or pre-post experimental (Boudreau and Godin, 2014). All the RCT studies provided information of the intervention and the control groups. The sample sizes of studies ranged from 61 (Gucciardi et al., 2007) to 365 (Boudreau and Godin, 2014). The samples varied across the studies for intervention (ranging from 36 to 166) and control groups (ranging from 25 to 159). The length of study for interventions also varied (3 to 12 months) with follow-ups from 1, 3, 6 and 12 months. Self-reported measures and validated TPB questionnaires were used in all the studies; one RCT included objective measures of PA (Plotnikoff et al., 2014a).

Table 2

TPB studies predicting intentions and behaviours in populations with diabetes or pre-diabetes (n = 16).

Authors (year) Country	Study population (n) & characteristics	Study design	Behavioural measure (Outcomes)	TPB variables tested (and/or moderators)	Results [predicted intention and behaviour & variance explained (%)]		Study quality (6)
					Predicting intentions	Predicting behaviour	
Blue (2007) (United States)	Adults at risk of T2D (n = 106); M = 33 (31.2%), F = 73 (68.8%) Age range: 31–71 years Mean BMI = 34 kg/m ² Mean age: not reported	Cross-sectional	Physical activity (PA) and HE questionnaire	A, SN, PBC, Intention, Moderator Perceived diabetes risk.	Physical activity (intention) A ($\beta = 0.09$) SN ($\beta = 0.35^*$) PBC ($\beta = 0.43^*$) Perceived risk ($\beta = 0.03$) TPB Variance explained: 63% Healthy eating (intention) A ($\beta = 0.34^*$) SN ($\beta = 0.28^*$) PBC ($\beta = 0.44^*$) Perceived risk ($\beta = 0.03$) Variance explained: 76%	Not reported	1
Boudreau and Godin (2009) (Canada)	Adults with T2D ^a (n = 501) M = 215 (43%) F = 286 (57%) Mean age = 56.5 ± 6.5 years Mean BMI = 36.29 ± 8.25 kg/m ² Length of diagnosis: not reported	Cross-sectional	PA questionnaire	A, SN, PBC, Intention, Moderators Anticipated regret, Moral norm, Descriptive norm, Past behaviour	A ($\beta = 0.27^{***}$) SN ($\beta = 0.09^*$) PBC ($\beta = 0.52^{***}$). Variance explained: 59.7% Add regret; moral & descriptive norm Regret ($\beta = 0.08^*$) Moral norm ($\beta = 0.31^{***}$) Norm ($\beta = 0.41$) Variance explained: 67% Hierarchical regression Step 1: Past behaviour ($\beta = 0.43^{**}$) Variance explained: 18% Step 2 A ($\beta = 0.22^{**}$) PBC ($\beta = 0.21^{**}$) Variance explained: 50% (added 32%) Step 3 A ($\beta = 0.10^*$) PBC ($\beta = 0.37^{***}$) Moral Norm ($\beta = 0.45^{***}$) Variance explained: 63% Moral norm mediated relationship between past behaviour and I	Not reported	2
Boudreau and Godin (2014) (Canada)	Adults with T2D (n = 325) M = 167 (51.4%) F = 158 (44.6%) Mean age = 49.5 ± 7.8 years At baseline (randomised) Intervention Computer tailored intervention (n = 166) (54%) Computer tailored intervention (print 1 & 2) developed according to data collected. Control Generic intervention (n = 159) (69%) Generic intervention received 2 prints based on general order from selected prints, websites and brochures	Randomised control trial (RCT) Pre-test/post-test experimental design Length of study: 8 months Evaluation & follow-ups: Time 0 (baseline), Time 1 (1 month follow-up after 1st print) Time 2 (1 month follow-up after 2nd print) Time 3 (1 month follow-up after both prints) Time 4 (3 months follow-up)	Godin leisure-time exercise questionnaire And TPB to measure intention	A, SN, PBC, Intention Moderator Participation level in leisure-time physical activity	Step 1: Past behaviour ($\beta = 0.43^{**}$) Variance explained: 18% Step 2 A ($\beta = 0.22^{**}$) PBC ($\beta = 0.21^{**}$) Variance explained: 50% (added 32%) Step 3 A ($\beta = 0.10^*$) PBC ($\beta = 0.37^{***}$) Moral Norm ($\beta = 0.45^{***}$) Variance explained: 63% Moral norm mediated relationship between past behaviour and I	I ($\beta = 0.34^{***}$) PBC ($\beta = 0.16^*$) Past behaviour ($\beta = 0.27^{***}$) Experimental condition ($\beta = 0.20^{***}$) Variance explained: 43% At Baseline Mean behavioural score 2.85 ± 1.48 One month follow-up Mean behavioural score 2.85 ± 1.48 I and PBC mediated relationship between moral norm and PA	3
Chapman et al. (1995) (United States)	Male adults with T2D (n = 48) Mean age = 67 ± 4.3 years Mean BMI = 30.5 ± 5 kg/m ² Mean HbA1c = 12 ± 2.8%	Cross-sectional	Dietary adherence	A, SN, PBC, Intention Moderators Perceived susceptibility Perceived severity Perceived costs and benefits	Baseline A ($\beta = 0.829$) SN ($\beta = -0.001^{**}$) PBC ($\beta = 0.111$) Variance explained: 69% SN ($\beta = -0.410^{**}$) PBC ($\beta = 0.350$) Variance explained: 51% Positive partner support I ($\beta = 0.359^{**}$), SN ($\beta = -0.241^{**}$) Planning ($\beta = -0.282^*$), Adherence ($\beta = 0.455^{**}$) Negative partner support I ($\beta = 0.309^{**}$), SN ($\beta = -0.208^{**}$), Planning ($\beta = -0.181^*$), Adherence	I ($\beta = 0.400^*$) A ($\beta = 0.472$) SN ($\beta = -0.842$) PBC ($\beta = 0.366$) (F = 4.439*) Variance explained: not reported	2
Costa et al. (2012) (Portugal)	Adults with T2D (n = 179) M = 103 (57.5%) F = 76 (42.5%) Mean age = 59.6 ± 10.33 years Age of 2D diagnosis: <12 months	Cross-sectional	Self-monitoring of blood glucose – (TPBQ-SMBG) questionnaire Multidimensional Diabetes Questionnaire (MDQ) Revised Summary of Diabetes Self Care Activities (SDSCA) HbA1c	A, SN, PBC, Intention Moderators Partner support (PS): positive such as encouragement and negative such as warning Self-efficacy, Planning, Adherence to SMBG	Positive partner support I ($\beta = 0.359^{**}$), SN ($\beta = -0.241^{**}$) Planning ($\beta = -0.282^*$), Adherence ($\beta = 0.455^{**}$) Negative partner support I ($\beta = 0.309^{**}$), SN ($\beta = -0.208^{**}$), Planning ($\beta = -0.181^*$), Adherence	Predictors of adherence to SMBG I ($\beta = 0.181^{**}$) PS ($\beta = 0.09^{**}$) Variance explained: 36.6% PS mediator between I and adherence to SMBG I (adherence to SMBG) ($\beta = 0.513^{**}$) I (positive support) ($\beta = 0.359^{**}$)	2

(continued on next page)

Table 2 (continued)

Authors (year) Country	Study population (n) & characteristics	Study design	Behavioural measure (Outcomes)	TPB variables tested (and/or moderators)	Results [predicted intention and behaviour & variance explained (%)]		Study quality (6)
					Predicting intentions	Predicting behaviour	
Davies et al. (2010) (Australia)	Adults with T2D (n = 74) M = 32 (43%) F = 42 (57%) Mean age = 61 ± 11.12 years BMI: not reported	Prospective study Baseline data (initial questionnaire) <u>Follow-up</u> 2 weeks follow-up to collect PA behaviour data	PA using Godin leisure-time exercise questionnaire	A, SN, PBC, Intention, Moderator Personality traits.	($\beta = 0.346^{**}$), HbA1c control ($\beta = -0.160^{**}$). <u>Adherence to SMBG</u> I ($\beta = 0.513^{**}$), A ($\beta = 0.173^*$), SN ($\beta = 0.388^{**}$), PBC ($\beta = 0.202^{**}$), Planning ($\beta = 0.371^{**}$). <u>High levels of HBA1c</u> I ($\beta = 0.168^*$) SN ($\beta = 0.170^*$), Adherence ($\beta = 0.183^*$) –Partner support ($\beta = 0.160^*$) A ($\beta = 0.28^*$) SN ($\beta = 0.08$) PBC ($\beta = 0.61^{**}$) <u>Add personality measures</u> A ($\beta = 0.27^*$) SN ($\beta = -0.08$) PBC ($\beta = 0.65^{**}$) Past behaviour ($\beta = 0.265^{**}$) <i>Variance explained: 73%</i> <u>Diabetes self-management</u> A ($\beta = 0.199^{***}$), SN ($\beta = 0.203^{***}$) SE ($\beta = 0.322^{***}$) K ($\beta = 0.099^*$) Physician's visit ($\beta = -0.118^{***}$) <i>Variance explained: 41.6%; 31.3% explained by SE</i>	PS (adherence to SMBG) ($\beta = 0.357^{**}$) Effect of positive support between I and adherence to SMBG ($\beta = 0.388^{**}$) <u>Step 1:</u> I ($\beta = 0.53^{**}$) <u>Step2: Add A, SN, PBC</u> I ($\beta = 0.41^*$) <u>Step 3: Add personality measures</u> I ($\beta = 0.41^*$) <i>Variance explained: 28%</i>	1
Didarloo et al. (2012) (Iran)	Adult women with T2D (n = 352) Age range: 18–65 Mean age: not reported Length of diagnosis: 1–10years BMI < 29.9 (46.9%) BMI > 30 (40.1%) kg/m ²	Cross-sectional	Diabetes self-care behaviour questionnaire (SDSCA)	A, SN, PBC, Intention Moderator Self-efficacy (SE) Knowledge (K) Education (E) Physician's visit	A ($\beta = 0.217$) SN ($\beta = -0.014$) PBC ($\beta = 0.617$) <i>Variance explained: 49%</i>	<u>Diabetes self-management</u> I ($\beta = 0.209^{***}$) A ($\beta = 0.15$) SN ($\beta = 0.075$) SE ($\beta = 0.122^*$) K ($\beta = 0.193^{***}$). Physician's visit ($\beta = -0.237^{***}$) <i>Variance explained: 25.3%; 11.4% explained by SE</i>	2
Gatt and Sammut (2008) (Malta)	Adults with T2D (n = 200) M = 39 (39%) F = 61 (61%) Mean age = 64 years Length of diagnosis: 6 years	Cross-sectional	Diabetes self-care behaviours (SDSCA) questionnaire	A, SN, PBC, Intention	A ($\beta = 0.136$) SN ($\beta = 0.139$) PBC ($\beta = 0.296^*$) <i>Variance explained: 18.1%</i> <u>Intervention effects</u> Improvement pre-to post intervention in A ($\Delta = 2.28$, SN ($\Delta = 0.43$, PBC ($\Delta = 0.37$ and I ($\Delta = 0.37$); self-reported nutrition adherence ($\Delta = 0.39$ and HbA1c ($\Delta = -0.51\%$. HbA1c decreased from 7.4% ± 1.6 at baseline to 6.9% ± 1.3** Nutrition adherence and TPB constructs were not significantly correlated with HbA1c	I ($\beta = 0.072$) PBC ($\beta = 0.487$) <i>Variance explained: 30%</i>	4
Gucciardi et al. (2007) (Canada)	Adults with T2D (n = 61) <u>Intervention (n = 36)</u> M = 11 (30.6%) F = 25 (69.4%) Mean age = 59 ± 12.1 years Mean BMI = 35 ± 6.6 kg/m ² Length of diagnosis (1 ± 7.5) <u>Control (n = 25)</u> M = 8 (32%) F = 17 (68%) Mean age = 60.4 ± 7.92 years Mean BMI = 34.9 ± 5.6 kg/m ² Length of diagnosis (4 ± 2.5) years	Randomised control trial <u>Length of study:</u> 3 months controlled trial design (16 h over 3 days) <u>Intervention</u> Counselling & group education (5–8 people) <u>Control</u> Individual Counselling <u>Evaluation & follow-ups:</u> Pre-protocol analysis to examine efficacy Baseline and 3 month follow-up	Nutrition management; nutrition adherence & glycaemic control questionnaire TPB questionnaire on nutrition management	A, SN, PBC, Intention	A ($\beta = 0.136$) SN ($\beta = 0.139$) PBC ($\beta = 0.296^*$) <i>Variance explained: 18.1%</i> <u>Intervention effects</u> Improvement pre-to post intervention in A ($\Delta = 2.28$, SN ($\Delta = 0.43$, PBC ($\Delta = 0.37$ and I ($\Delta = 0.37$); self-reported nutrition adherence ($\Delta = 0.39$ and HbA1c ($\Delta = -0.51\%$. HbA1c decreased from 7.4% ± 1.6 at baseline to 6.9% ± 1.3** Nutrition adherence and TPB constructs were not significantly correlated with HbA1c	A ($\beta = -1.03$) SN ($\beta = 0.338^*$) PBC ($\beta = 0.056$) I ($\beta = 0.377^{**}$) <i>Variance explained: 27.6%</i>	3
Hardeman et al. (2011a,b) (United Kingdom)	Adults at risk of T2D (n = 365) M = 139 (38%) F = 226 (62%) Mean age = 40.4 ± 6 years Mean BMI: not reported Parental history of diabetes and sedentary	Prospective study (Cohort analysis based a ProACT RCT trial-see Kinmonth et al. (2008)) <u>Length of study:</u> 1 years <u>Follow-up:</u> Followed over 12 months	Self-reported and objective measure of PA EPAQ2 questionnaire for self-reported PA Objective PA (Heart rate and energy expenditure) in dayPAR (ratio of daytime energy	A, SN, PBC, Intention, (Direct & indirect)	<u>Model 1 (direct measures)</u> <u>Baseline:</u> AA ($\beta = 0.385^{***}$) PBC ($\beta = 0.225^*$) <i>Variance explained: 53%</i> At 6 months: AA ($\beta = 0.263^{***}$)	I and PBC did not predict PA behaviour for both direct and indirect measures at 6 months or 12 months	5

Hardeman et al. (2011) (United Kingdom)		using objective and self-reported measure Objective PA measured at baseline and 12 months Self-reported PA and cognitions measured at baseline, 6 months and 12 months 1 ⁰ and 2 ⁰ outcomes measured at baseline and after 1 year	expenditure to resting expenditure estimated using heart rate monitoring for 3 days)		SN ($\beta = 0.331^{**}$) PBC ($\beta = 0.785^{***}$) Variance explained: 97% At 12 months: AA ($\beta = 0.182^{****}$) PBC ($\beta = 0.757^{***}$) Variance explained: 89% Model 2 (Indirect measures) Baseline: IA ($\beta = 0.146$) AA ($\beta = 0.280^{****}$). PBC ($\beta = 0.344^{***}$) Variance explained: 37% At 6 months IA ($\beta = 0.396^{***}$) PBC ($\beta = 0.383^{***}$) Variance explained: 53% At 12 months IA ($\beta = 0.237^{*}$) AA ($\beta = 0.199^{**}$) PBC ($\beta = 0.445^{***}$) Variance explained: 47%		
Lakerveld et al. (2011) (The Netherlands)	Adults at risk of T2D (n = 622) M = 259 (42%) F = 358 (58%) Mean age = 43.7 ± 8 years Mean BMI: not reported	Cross sectional (Based on baseline data of a lifestyle randomised intervention trial)	Dietary behaviour, physical activity and smoking using Determinants of Lifestyle Behaviour Questionnaire (DLBQ) Three lifestyle behaviours (physical activity, dietary and smoking behaviour)	A, SN, PBC, Intention	Not reported	1	
Plotnikoff et al. (2008) (Canada)	Adults with T2D (n = 244) M = 131 (54%) F = 112 (45.9%) Mean age: 60.93 ± 11.23 years Age diagnosed: 51.95 ± 11.94 years Meet guidelines for aerobic PA (150 min mod PA / wk): n = 57 (23.5%) Meeting recommended guidelines for resistance training (3 times/week): n = 41 (17%)	Prospective study Follow-up 3 month follow-up that assessed aerobic PA and resistance training Data collected at (Time 1 – baseline) (Time 2–3 month assessment)	Self-reported aerobic PA (Godin Leisure-Time Exercise Questionnaire (GLTEQ) that also included resistance training item.	A, SN, PBC, Intention	Aerobic Exercise variance explained: 10% I ($\beta = 0.18^{*}$); A, I and gender Resistance training TPB Variance explained: 8%	4	
Plotnikoff et al. (2010b) (Canada)	Adults with T2D (n = 1614) M = 829 (51%) F = 785 (49%) Mean age: = 63.0 ± 12.1 years Mean BMI: = 29.8 ± 6.3 kg/m ² *Also looked at T1D	Prospective study Follow-up Time 1 – baseline data (n = 1614 T2D) 28% recommended PA at baseline. Time 2–6 months (n = 1193 (T2D)	PA using Godin leisure-time exercise questionnaire & resistance training	A, SN, PBC, Intention	Model 1 (baseline) I ($\beta = 0.42/0.40$) PBC ($\beta = 0.10/0.06$) Variance explained: 19% Model 2 (at 6 months) I ($\beta = 0.42/0.40$) PBC ($\beta = 0.12^{*}/0.09^{*}$) Variance explained: 8%	2	
					Aerobic Exercise A ($\beta = 0.38^{***}$) SN ($\beta = 0.30^{***}$) Age significantly associated with A ($\beta = -0.15^{***}$) and SN ($\beta = -0.26^{***}$) Gender associated with SN ($\beta = 0.13^{*}$) and PBC ($\beta = 0.15^{*}$) Variance explained = 39% Resistance training A ($\beta = 0.49^{***}$) SN ($\beta = 0.23^{**}$) Variance explained = 45% Model 1 (baseline) A ($\beta = 0.39^{*}/0.36^{*}$) SN ($\beta = 0.12^{*}/0.12^{*}$) PBC ($\beta = 0.33^{*}/0.34^{*}$) Variance explained: 40% Model 2 (at 6 months) A ($\beta = 0.37^{*}/0.37^{*}$) SN ($\beta = 0.17^{*}/0.14^{*}$) PBC ($\beta = 0.32^{*}/0.33^{*}$) Variance explained: 40%		

(continued on next page)

Table 2 (continued)

Authors (year) Country	Study population (n) & characteristics	Study design	Behavioural measure (Outcomes)	TPB variables tested (and/or moderators)	Results [predicted intention and behaviour & variance explained (%)]		Study quality (6)
					Predicting intentions	Predicting behaviour	
Plotnikoff et al. (2014a) (Canada)	Women with T2D (n = 93) Mean age = 59.6 ± 11.3 years No significant difference with age and BMI <u>Control group (n = 44)</u> Standard PA materials <u>Intervention group (n = 49)</u> Standard PA materials stage –matched printed material and telephone counselling (weekly call for 1 month followed by biweekly calls for another month and then monthly 15 min call till end of intervention)	Randomised control trial (based on secondary data from ADAPT) <u>Length of study:</u> 12 month randomised control trial with 6 month and 12 month follow-up Data collected at baseline, 6 and 12 months Part of ADAPT RCT Study evaluating theory-based interventions to increase PA in T2D adults	Self-reported (Godin Leisure Time Exercise Questionnaire) and objective measure of PA steps/per 3 days (Yamax Digiwalker SW200 pedometer) at baseline and 12 months	A, SN, PBC, Intention and Moderators: Severity; self-efficacy (SE-barrier) Response efficacy; Outcome expectations & Outcome expectations (pros & cons); Implementation intentions; Fear; Vulnerability	<u>Intervention effects</u> Implementation intentions significantly increased <u>Action theory test (A)</u> Implementation I (A = 0.20, SE 0.06 ***) I (A = 0.23, SE 0.08 **) SE (A = 0.17, SE 0.00 **) PBC (A = 0.12, SE 0.07 *) <u>Conceptual theory test (B)</u> Outcome expectations (B = 4820, SE 2070*) A (B = 4680, SE 1650**) PBC (B = 3260, SE 1260**)	<u>After 12 months (total intervention effects on PA)</u> Objectively measures PA increased in intervention group (C = 2001 steps, SE 832 **) Intention mediator of objective PA (23% explained variance) Barrier SE mediated intervention effects on objective PA (24% explained variance) PBC mediated intervention effects on objective PA (18% explained variance)	4
Plotnikoff et al. (2014b) (Canada)	M = 154 (53.8%) F = 133 (46.2%) Mean age = 61.6 ± 11.8 years Mean BMI = 30.3 ± 6.0 kg/m ² Baseline n = 287 6 month n = 210 12 months n = 208 18 months n = 192 <u>Assessment for study at Time 1 (baseline) and Time 2 (12 months)</u>	Longitudinal prospective study (based on secondary data from ADAPT) <u>Length of study</u> Three 6 month time intervals (baseline-6; 6–12 months; 12–18 months) <u>Follow-up</u> 6 months, 12 months and 18 months	Self-reported (Godin Leisure Time Exercise Questionnaire) Objective measure of PA steps/per 3 consecutive days (Yamax Digiwalker SW200 pedometer) at baseline, 6 months, 12 and 18 months (Only the baseline and 12 month assessment was used for this study)	Intention, A, SN, PBC Moderators: Severity; Response efficacy; Outcome expectations Vulnerability Self-efficacy Social Support	<u>At time 1</u> A (β = 0.20) SN (β = 0.24*) PBC (β = 0.25) TPB explained for 36% variance for intention <u>At time 2</u> A (β = 0.49*) SN (β = 0.03) PBC (β = 0.32*) TPB explained for 47% variance for intention A (β = 0.24**) SN (β = 0.35**) PBC (β = 0.13) <u>Variance explained: 28%</u> Add past behaviour A (β = 0.19**) SN (β = 0.32***) Past behaviour (β = 0.20**) <u>Variance explained: 31%</u>	<u>At time 1</u> TPB explained for 9% variance for objective PA TPB explained for 14% variance for self-reported PA <u>At time 2</u> I (β = 0.16*) TPB explained for 49% variance for objective PA TPB explained for 27% variance for self-reported PA PBC (β = 0.21*) I (β = 0.22*) <u>Add planning & past behaviour</u> Planning (β = 0.22*) Past behaviour (β = 0.26**) <u>Variance explained: 22%</u>	4
White et al. (2010) (Australia)	Adults with T2D (n = 184) M = 76 (42%) F = 107 (58%) Mean age = 60.71 Length of diagnosis: (10.79 ± 11.74)	Prospective study Intervention (weekly 2 hour sessions over 4 week period) <u>Follow-up</u> 1 month after completion of baseline questionnaire	Consumption of foods in low-saturated fats questionnaire	A, SN, PBC, Intention Moderators: Past behaviour Planning	A (β = 0.24**) SN (β = 0.35**) PBC (β = 0.13) <u>Variance explained: 28%</u> Add past behaviour A (β = 0.19**) SN (β = 0.32***) Past behaviour (β = 0.20**) <u>Variance explained: 31%</u>	PBC (β = 0.21*) I (β = 0.22*) <u>Add planning & past behaviour</u> Planning (β = 0.22*) Past behaviour (β = 0.26**) <u>Variance explained: 22%</u>	1

Indicates statistical significance when the study reported significant findings ($p < 0.05$; ** $p < 0.01$; *** $p < 0.001$); β = standardised beta.

I – Intention; B – Behaviour; A – Attitude; SN – Subjective norm; PBC – Perceived behavioural control; AA – Affective attitude; CA Cognitive attitude; IA – Instrumental attitude; SE – Self-efficacy; K – Knowledge; CL – Cost likelihood; BL – Benefit likelihood; T1 (Time 1); T2 (Time 2).

^a Type 2 diabetes (T2D).

Prospective studies

Of the six prospective studies, three originated from Canada (Plotnikoff et al., 2008, 2010b, 2011, 2014b), two from Australia (Davies et al., 2010; White et al., 2010) and one from the United Kingdom (Hardeman et al., 2011b). Whilst five studies were on PA behaviours (Davies et al., 2010; Hardeman et al., 2011b; Plotnikoff et al., 2008, 2010b, 2014b), one study examined dietary behaviour (White et al., 2010) in adult populations with T2D. One study included adults at-risk of diabetes ($n = 365$, 62% female) (Hardeman et al., 2011b). Participants in these studies were randomly selected through a diabetes registry (Davies et al., 2010; Hardeman et al., 2011b; Plotnikoff et al., 2008, 2010b).

The age and gender composition for the studies varied $n = 74$, 57% women (Davies et al., 2010), $n = 365$, 62% women (Hardeman et al., 2011b), $n = 244$, 45.9% women (Plotnikoff et al., 2008), $n = 1614$, 49% women (Plotnikoff et al., 2010b), $n = 287$, 46.2% women (Plotnikoff et al., 2014b), $n = 184$, 58% women (White et al., 2010). The follow-up period varied from 2 weeks (Davies et al., 2010) to 18 months (Plotnikoff et al., 2014b).

Two studies objectively measured PA, one by counting steps over the three consecutive days using a Yamaz Digiwalker pedometer (Hardeman et al., 2011b; Plotnikoff et al., 2010b), and the other by monitoring energy expenditure and heart rate for three days. All the studies included validated psychometric instruments to measure intention and behavioural outcomes.

Cross-sectional studies

Seven cross-sectional studies were included in the review. These studies were from different locations with two from Canada (Blue, 2007; Chapman et al., 1995); one from the United States (Chapman et al., 1995); one from Portugal (Costa et al., 2012) and one from Malta (Gatt and Sammut, 2008). One study originated from the Netherlands (Lakerveld et al., 2011) and one from Iran (Didarloo et al., 2012).

One study assessed PA intentions (Boudreau and Godin, 2009). Two studies measured dietary behaviours (Chapman et al., 1995; Lakerveld et al., 2011) and one study examined combined PA and HE (Blue, 2007). One study examined SMBG (Costa et al., 2012) and examined diabetes self-care (Didarloo et al., 2012; Gatt and Sammut, 2008).

Four cross-sectional studies included adults with T2D, sample size ranging from 179 (Costa et al., 2012) to 501 (Boudreau and Godin, 2009). A study with elderly male adults ($n = 48$) (Chapman et al., 1995) and another focussed on adult females with T2D ($n = 352$) (Didarloo et al., 2012) were also included. Two studies included adults at risk of diabetes $n = 106$, 68.8% women, (Blue, 2007), $n = 622$, 58% women (Lakerveld et al., 2011).

Intentions were reported by three studies (Blue, 2007; Boudreau and Godin, 2009; Lakerveld et al., 2011) whilst four studies also reported behaviour (Chapman et al., 1995; Costa et al., 2012; Didarloo et al., 2012; Gatt and Sammut, 2008). All studies included self-reported measures.

Quality assessment of studies

The quality assessment of the studies is presented in Appendix Table A1. The majority of the included studies in this review had a moderate ($n = 6$) to high ($n = 9$) risk of bias. Only one study scored a five (Hardeman et al., 2011b) (low risk of bias). Reporting of eligibility criteria was evident in 11 of the 16 studies. Inadequate reporting of randomisation methods and power calculations were common issues identified by assessing risk of bias. For example, only six studies reported randomisation procedures (Chapman et al., 1995; Gucciardi et al., 2007; Hardeman et al., 2011b; Plotnikoff et al., 2008, 2014b) and only four studies included power calculations details (Boudreau and Godin, 2014; Gatt and Sammut, 2008; Hardeman et al., 2011b; Plotnikoff et al., 2014a, b). Although one study did not provide information on power calculation, it used a sub-set sample ($n = 93$ women only) which was part of a randomised control trial that reported power (Plotnikoff et al., 2014a). Twelve studies included a validated measure for behaviour. These studies provided the sources and details regarding the reliability of the behaviour assessment. Seven studies reported acceptable reliability for both internal consistency and test–retest reliability for the TPB measures.

Overview of the evidence

Table 3 outlines the percentage of explained variance for specific behaviours across study designs. Overall, a wide range of variance was explained for intention (18–76%) and behaviour (8–43%) for all diabetes-related behaviours. Cross-sectional studies presented slightly stronger evidence for intentions (28–76%) compared to prospective design (28–73%) and RCTs (18–63%). The explained variance for all behaviours was 25–36% from cross-sectional; 8–22% from prospective and 18–43% from RCT studies.

Studies describing healthy eating behaviours found 18%–69% of explained variance for intention and 22%–28% for behaviour (Blue, 2007; Chapman et al., 1995; Gucciardi et al., 2007; Lakerveld et al., 2011; White et al., 2010). For PA studies, 18–73% of variance in intentions and 8%–49% of variance was explained by the TPB (Plotnikoff et al., 2014b). One cross-sectional study reported explained variance (36%) for self-monitoring of blood glucose (Costa et al., 2012). The explained variance for diabetes self-care intentions from cross-sectional evidence was (42%–49%) and (25–30%) for behaviour (Didarloo et al., 2012; Gatt and Sammut, 2008).

Discussion

The objective of this paper was to examine the predictive utility of the TPB variables in populations at-risk (pre-diabetes) and with T2D and included healthy eating or dietary change, physical activity, self-monitoring of blood glucose and diabetes self-care. The review identified 16 eligible studies. The majority of studies had a high to moderate risk of bias (15 studies) with one study identified as low risk of bias. However, a very limited number of studies reported acceptable

Table 3
Explained variance for intentions and behaviours across study design.

	Cross-sectional study ($n = 7$)		Prospective study ($n = 6$)		Randomised controlled trial ($n = 3$)	
	Intention (%)	Behaviour (%)	Intention (%)	Behaviour (%)	Intention (%)	Behaviour (%)
Healthy eating ($n = 3$)	28%–69%	–	28%–31%	22%	18%	28%
Physical activity ($n = 8$)	60%–67%	–	31%–73%	8%–28%	18%–63%	18%–49%
Dietary & PA ($n = 2$)	HE	56%–76%	–	–	–	–
	PA	41%–63%	–	–	–	–
Self-monitoring blood glucose ($n = 1$)	–	36%	–	–	–	–
Diabetes self-care ($n = 2$)	42%–49%	25%–30%	–	–	–	–
Range (%)	28%–6%	6%–30%	28%–31%	8%–22%	18%–63%	18%–3%

*Range in % explained variance across different behaviours and study design.

reliability for both internal consistency and test–retest reliability for TPB measures suggesting this may have limited the predictive ability of the TPB measures across the studies in this review (Boudreau and Godin, 2009, 2014; Gatt and Sammut, 2008; Plotnikoff et al., 2008).

Intention as strongest predictor of behaviour

A wide range of explained variance was observed for diabetes-related behaviours (Table 3). Of the studies identified in this review, intention emerged as the most predictive construct for all diabetes related-behaviour. The explained variance was stronger for intention (18–76%) compared to behaviour (8–43%) (Table 3). Previous meta-analyses have demonstrated similar findings for health related behaviours (40–49% for intentions and 26–36% for behaviour) (Armitage and Conner, 2000; Downs and Hausenblas, 2005; McEachan et al., 2011) suggesting that intention is an important mediator for the relationship between the TPB constructs (A, SN and PBC) and behaviour.

TPB constructs predicting intention for different behaviours

The predictive utility of the TPB varied widely for different behaviours and sub-populations. There was inconsistent evidence regarding the most predictive construct for explaining intention across the behaviours.

Healthy eating

The key predictive constructs for dietary behaviour intentions varied and included A (Blue, 2007; White et al., 2010), SN (Chapman et al., 1995; Lakerveld et al., 2011), and PBC (Blue, 2007; Gucciardi et al., 2007; Lakerveld et al., 2011; White et al., 2010). For populations at risk, A and PBC were the strongest predictor (63%) (Blue, 2007) whilst in another study SN and PBC emerged as the strongest correlate for HE intentions (56%) (Lakerveld et al., 2011). On the other hand, White et al. (2010) reported A and SN to strongly predict intentions to eat foods low in saturated fats (28%) and PBC emerged as the strongest correlate of intention for nutrition adherence (18%) in adults with T2D (Gucciardi et al., 2007). These findings were less consistent with empirical studies that support A and PBC as strong predictors of intentions for healthy eating in general populations (Conner et al., 2002; Gardner and Hausenblas, 2006).

Physical activity

For PA studies, A and PBC were significant predictors of intention (Boudreau and Godin, 2009, 2014; Davies et al., 2010; Hardeman et al., 2011b; Plotnikoff et al., 2010b). For example, Boudreau and Godin (2009) found attitudes (A) strongly predict for intentions to be physically active. In a RCT of adults with T2D, PBC emerged as the strongest correlate to intention (Boudreau and Godin, 2014) whereas, SN emerged as the strongest correlate of intention (Plotnikoff et al., 2008). However, A and PBC were the strongest predictors for intention in adults at risk of diabetes (Hardeman et al., 2011b).

Diabetes self-care and self-monitoring blood glucose

In a study of women with T2D, self-efficacy was the strongest predictor for diabetes self-care intentions (Didarloo et al., 2012). Social norms (SN), adherence and partner support strongly correlated with intention to self-monitoring blood glucose for adults with T2D. (Costa et al., 2012).

Study designs

When comparing results by study design, intention was consistently more predictive for explaining diabetes-related behaviour in cross-sectional studies. Intention also emerged as the most predictive construct for explaining behaviour in prospective and RCT studies. This review reported a greater percentage of explained variance in intention compared to behaviour. The explained variance for PA from

cross-sectional evidence was stronger for intentions (60–67%) compared to prospective (31–73%) and RCT (37–63%) studies. Similar findings were observed for HE intentions from cross-sectional (28–69%), prospective (28–31%) and RCT (18%) studies.

Unlike intention predictions, the TPB accounted for greater variance in explaining behaviour from RCT (8–43%) compared to cross-sectional (6–30%) and prospective (8–22%) studies. The explained variance for HE were stronger from RCT (28%) than from prospective (22%) and cross-sectional evidence (6–12%). Similarly, the explained variance from RCT (18–43%) was greater for PA than prospective studies (8–28%). However, individual studies that looked at cross-sectional and prospective analysis in this review contradicted these findings. For example, a study on PA in adults with T2D by Plotnikoff et al (2010b) found 19% of variance from a cross-sectional analysis and 8% of variance from a prospective model. Similar effects were reported for lower variance prediction of prospective studies (McEachan et al., 2011) compared to reviews that included cross-sectional and longitudinal studies (Armitage and Conner, 2001; Hagger et al., 2002). A meta-analysis of social cognitive theory and PA also found no difference in explained variance between cross-sectional and longitudinal studies on PA behaviour (Young et al., 2014). Another study of PA with adults reported negligible difference between cross-sectional and longitudinal tests. Furthermore, meta-analysis of prospective studies have shown that study design significantly moderated behavioural effect sizes in their meta-analysis of the TPB, where model with a shorter time frame explained more variance than models using a longer time frame (McEachan et al., 2011).

These differences between the study designs suggest that methodological factors such as length of follow-up and objective versus self-reported behaviour measures may moderate the effectiveness of the TPB between the studies (Ajzen, 2011b). For instance, temporal distance between measurement of intentions and observed behaviour were found to be a limiting condition for prospective studies (McEachan et al., 2011).

The findings also support the argument that the variation in terms of strength predictions between constructs is likely to vary for different behaviours and populations (Ajzen, 2011a). This suggests that the nature of behaviour may be an important factor in the predictive utility of the TPB (Ajzen, 2011a). Predicting intentions for specific behaviour and population is important for identifying underlying beliefs (or indirect measures such as behavioural, normative or control beliefs) that distinguish between individuals who perform (or intend to perform) and individuals who do not perform (or intend to perform) the behaviour (s) (Ajzen, 2011a).

The different predictive strengths further suggest that other mediating variables may account for unexplained variance which would be useful for predicting self-care behaviours in individuals with T2D. Studies that included: perceived risk (Blue, 2007); regret (Boudreau and Godin, 2009); moral norms (Boudreau and Godin, 2009, 2014); personality measures (Davies et al., 2010); self-efficacy (Didarloo et al., 2012); past behaviours and planning (White et al., 2010); partner support (Costa et al., 2012); and age and gender (Plotnikoff et al., 2014a, b) were considered important mediators for the intentions–behaviour relationship, and added significant explained variance to the model (Plotnikoff et al., 2010b).

Despite the variability across different behaviours, these findings may provide guidance as to which variables to target when attempting to change different health behaviours, particularly in populations with T2D or pre-diabetes (at-risk) (Jennings et al., 2014; Plotnikoff et al., 2013b; White et al., 2012). The review of the TPB provides information for choice of interventions to improve self-care or self-management practices and has future implications for use in the development of effective interventions (McEachan et al., 2011).

Strengths and limitations

Although this study is the first to systematically review the utility of the TPB in populations at-risk (pre-diabetes) and type 2 diabetes, the

predictive nature and strength of the TPB determinants were inconclusive across the studies for different diabetes-related behaviours. Separate analyses of populations at risk and those with diabetes may provide a better indication of the differences in the relationship between the TPB variables. When interpreting the findings, limitations must be considered within this research area. A large proportion of variance for behaviour remains unexplained within the TPB studies. Future research to test models which include mediating factors such as psychosocial and ecological (environmental, social, political) variables is required. A majority of the TPB studies reviewed were cross-sectional designs. It is important to acknowledge that cross-sectional studies do not include appropriate temporal spacing, which is necessary to determine causality (Ajzen, 2011a). As such, high quality prospective studies are required to improve understanding of the possible causal associations between the TPB variables and behaviour in populations at-risk of (pre-diabetes) and with T2D. The variability in measurement choice (for both cognitive and behaviour constructs) within each of the reviewed studies compromises the true strength of the TPB to predict behaviour. A majority of the studies in this review employed self-reported measures of behaviour and therefore are likely to have introduced reporting bias. Despite these limitations, this review has several strengths which includes: a comprehensive search strategy across several databases; criteria for assessing study quality adapted from STROBE (von Elm et al., 2007) and CONSORT (Moher et al., 2010); a broad range of behaviours related to diabetes-management; and predictive constructs used to explain intentions and behaviours for two specific sub populations.

Future directions

At present, the available evidence for the utility of the TPB for describing intention and behaviours in general and culturally and linguistically diverse (CALD) populations with diabetes or pre-diabetes is limited. More research is needed in testing models based on psychosocial cognitive variables that explain behavioural intentions and behaviour across different behaviours. There is also a need for more longitudinal studies and/or RCT or intervention studies to examine behaviour change. This has significant implications for developing interventions based on effective diabetes management strategies (Boudreau et al., 2011; Jennings et al., 2014; White et al., 2012).

Conclusion

This systematic review revealed a wide range of variance in intention (18–76%) and diabetes-related behaviours (8–43%) in populations with T2D and at-risk (pre-diabetes) explained by the TPB. It highlighted the differences in predictive utility the TPB for specific diabetes-related behaviours. The review found the explained variance for PA intentions and behaviour was 18%–76% and 8%–49%, respectively; 18%–69% and 6%–28% of explained variance for HE intention and behaviour; 36% of explained variance for self-monitoring of blood glucose; and 42%–49% and 25–30% of explained variance in intention and behaviour for diabetes self-care. A wide range of explained variance also suggests that the TPB determinants are behaviour specific and depend largely on the target populations. Identifying target specific beliefs based on the predictive TPB determinants are important when designing behavioural interventions for different diabetes populations.

Author disclosures

The authors do not have any conflicts of interest to disclose.

Author contributions

All authors fulfil the criteria for authorship by having taken part in the conception, design, process, analysis and write-up of this article. All authors read and approved the final manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.pmedr.2015.04.006>.

References

- Ajzen, I., 2011a. The theory of planned behaviour: reactions and reflections. *Psychol. Health* 26 (9), 1113–1127.
- Ajzen, I., 2011b. Theory of Planned Behavior. In: Van Lange, Paul A.M., Kruglanski Arie, W., Higgins, E. Tory (Eds.), *Handbook of Theories of Social Psychology: Volume One*. vol. 1. SAGE, p. 438.
- American Association of Diabetes Educators, 2009. Aade guidelines for the practice of diabetes self-management education and training (Dsme/T). *Diabetes Educ.* 35 (3 Suppl.), 85S–107S. <http://dx.doi.org/10.1177/0145721709352436>.
- American Diabetes Association, 2013. Diagnosis and classification of diabetes mellitus. *Diabetes Care* 36 (Suppl. 1), S67–S74.
- Armitage, C., Conner, M., 2000. Social cognition models and health behavior: a structured review. *Psychol. Health* 15, 173–189.
- Armitage, C.J., Conner, M., 2001. Efficacy of the theory of planned behaviour: a meta-analytic review. *Br. J. Soc. Psychol.* 40 (4), 471–499. <http://dx.doi.org/10.1348/014466601164939>.
- Blue, C.L., 2007. Does the theory of planned behavior identify diabetes-related cognitions for intention to be physically active and eat a healthy diet? *Public Health Nurs.* 24 (2), 141–150.
- Boudreau, F., Godin, G., 2009. Understanding physical activity intentions among French Canadians with type 2 diabetes: an extension of Ajzen's theory of planned behaviour. *Int. J. Behav. Nutr. Phys. Act.* 6 (1), 35.
- Boudreau, F., Godin, G., 2014. Participation in regular leisure-time physical activity among individuals with type 2 diabetes not meeting Canadian guidelines: the influence of intention, perceived behavioral control, and moral norm. *Int. J. Behav. Med.* 1–9 <http://dx.doi.org/10.1007/s12529-013-9380-4>.
- Boudreau, F., Godin, G., Poirier, P., 2011. Effectiveness of a computer-tailored print-based physical activity intervention among French Canadians with type 2 diabetes in a real-life setting. *Health Educ. Res.* 26 (4), 573–585. <http://dx.doi.org/10.1093/her/cyr008>.
- Chapman, K.M., Ham, J.O., Liesen, P., et al., 1995. Applying behavioral models to dietary education of elderly diabetic patients. *J. Nutr. Educ.* 27 (2), 75–79. [http://dx.doi.org/10.1016/s0022-3182\(12\)80345-1](http://dx.doi.org/10.1016/s0022-3182(12)80345-1).
- Conner, M., Norman, P., Bell, R., 2002. The theory of planned behavior and healthy eating. *Health Psychol.* 21 (2), 194–201. <http://dx.doi.org/10.1037/0278-6133.21.2.194>.
- Costa, V., Pereira, M.G., Pedras, S., 2012. Partner support, social-cognitive variables and their role in adherence to self-monitoring of blood glucose in type 2 diabetes. *Eur. Diabetes Nurs.* 9 (3), 81–86.
- Davies, C., 2008. The relationship between the theory of planned behaviour, past exercise behaviour and intention in individuals diagnosed with type 2 diabetes. *Innov. Dev.* 5 (2), 25–32.
- Davies, C.A., Mummery, W.K., Steele, R.M., 2010. The relationship between personality, theory of planned behaviour and physical activity in individuals with type II diabetes. *Br. J. Sports Med.* 44 (13), 979–984.
- Didarloo, A., Shojaeizadeh, D., Ardebili, H., et al., 2011. Factors influencing physical activity behavior among Iranian women with type 2 diabetes using the extended theory of reasoned action. *Diabetes Metab. J.* 35 (5), 513–522.
- Didarloo, A., Shojaeizadeh, D., Asl, R., et al., 2012. Prediction of self-management behavior among Iranian women with type 2 diabetes: application of the theory of reasoned action along with self-efficacy (Etra). *Iran. Red Crescent Med. J.* 14 (2), 86.
- Didarloo, A., Shojaeizadeh, D., Gharaaghaji Asl, R., et al., 2014. Psychosocial correlates of dietary behaviour in type 2 diabetic women, using a behaviour change theory. *J. Health Popul. Nutr.* 32 (2), 335–341.
- Downs, D.S., Hausenblas, H.A., 2005. The theories of reasoned action and planned behavior applied to exercise: a meta-analytic update. *J. Phys. Act. Health* 2 (1), 76–97.
- Fishbein, M., Ajzen, I., 2009. *Predicting and Changing Behavior*. Taylor & Francis.
- Fishbein, M., Ajzen, I., 2011. *Predicting and Changing Behavior: The Reasoned Action Approach*. Taylor & Francis.
- Funnell, M.M., Anderson, R.M., 2008. *Influencing Self-Management: From Compliance to Collaboration Type 2 Diabetes Mellitus*. Humana Press, pp. 455–466.
- Gardner, R.E., Hausenblas, H.A., 2006. Exercise and diet determinants of overweight women participating in an exercise and diet program: a prospective examination of the theory of planned behavior. *Women Health* 42 (4), 37–62.
- Gatt, S., Sammut, R., 2008. An exploratory study of predictors of self-care behaviour in persons with type 2 diabetes. *Int. J. Nurs. Stud.* 45 (10), 1525–1533.
- Glanz, K., Bishop, D.B., 2010. The role of behavioral science theory in development and implementation of public health interventions. *Annu. Rev. Public Health* 31, 399–418.
- Glanz, K., Rimer, B.K., Viswanath, K., 2008. *Health Behavior and Health Education: Theory, Research, and Practice*. John Wiley & Sons.

- Godin, G., Kok, G., 1996. The theory of planned behavior: a review of its applications to health-related behaviors. *Am. J. Health Promot.* 11 (2), 87–98. <http://dx.doi.org/10.4278/0890-1171-11.2.87>.
- Grade Working Group, 2004. Grading quality of evidence and strength of recommendations. *BMJ* 328 (7454), 1490.
- Gucciardi, E., DeMelo, M., Lee, R.N., et al., 2007. Assessment of two culturally competent diabetes education methods: individual versus individual plus group education in Canadian Portuguese adults with type 2 diabetes. *Ethn. Health* 12 (2), 163–187.
- Hagger, M.S., Chatzisarantis, N.L., Biddle, S.J., 2002. A meta-analytic review of the theories of reasoned action and planned behavior in physical activity: predictive validity and the contribution of additional variables. *J. Sport Exerc. Psychol.* 24, 3–32.
- Hardeman, W., Kinmonth, A.L., Michie, S., Sutton, S., 2011a. Theory of planned behaviour cognitions do not predict self-reported or objective physical activity levels or change in the proactive trial. *Br. J. Health Psychol.* 16 (1), 135–150. <http://dx.doi.org/10.1348/135910710X523481>.
- Hardeman, W., Michie, S., Kinmonth, A.L., Sutton, S., 2011b. Do increases in physical activity encourage positive beliefs about further change in the proactive cohort? *Psychol. Health* 26 (7), 899–914. <http://dx.doi.org/10.1080/08870446.2010.512662>.
- International Diabetes Federation, 2011. Diabetes Atlas. In: International Diabetes Federation (Ed.), 5th ed. International Diabetes Federation, Brussels, Belgium (Retrieved from <http://www.idf.org/diabetesatlas>).
- Jennings, C.A., Vandelanotte, C., Capercione, C.M., et al., 2014. Effectiveness of a web-based physical activity intervention for adults with type 2 diabetes—a randomised controlled trial. *Prev. Med.* 60 (0), 33–40. <http://dx.doi.org/10.1016/j.ypmed.2013.12.011>.
- Kinmonth, A.-L., Wareham, N.J., Hardeman, W., et al., 2008. Efficacy of a theory-based behavioural intervention to increase physical activity in an at-risk group in primary care (proactive uk): a randomised trial. *Lancet* 371 (9606), 41–48.
- Lakerveld, J., Bot, S.D., Chinapaw, M.J., et al., 2011. Measuring pathways towards a healthier lifestyle in the hoorn prevention study: the determinants of lifestyle behavior questionnaire (Dlbq). *Patient Educ. Couns.* 85 (2), e53–e58. <http://dx.doi.org/10.1016/j.pec.2011.01.014>.
- Lindström, J., Ilanne-Parikka, P., Peltonen, M., et al., 2006. Sustained reduction in the incidence of type 2 diabetes by lifestyle intervention: follow-up of the Finnish Diabetes Prevention Study. *Lancet* 368 (9548), 1673–1679.
- McEachan, R.R., Conner, M., Taylor, N.J., et al., 2011. Prospective prediction of health-related behaviours with the theory of planned behaviour: a meta-analysis. *Health Psychol. Rev.* 5 (2), 97–144. <http://dx.doi.org/10.1080/17437199.2010.521684>.
- Michie, S., Hardeman, W., Fanshawe, T., et al., 2008. Investigating theoretical explanations for behaviour change: the case study of proactive. *Psychol. Health* 23 (1), 25–39.
- Moher, D., Hopewell, S., Schulz, K.F., et al., 2010. Consort 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. *J. Clin. Epidemiol.* 63 (8), e1–e37. <http://dx.doi.org/10.1016/j.jclinepi.2010.03.004>.
- Nam, S., Chesla, C., Stotts, N.A., et al., 2011. Barriers to diabetes management: patient and provider factors. *Diabetes Res. Clin. Pract.* 93 (1), 1–9. <http://dx.doi.org/10.1016/j.diabres.2011.02.002>.
- NHMRC, 2001. National Evidence Based Guidelines for the Management of Type 2 Diabetes Mellitus. NHMRC Publications, Canberra.
- Plotnikoff, R.C., Courneya, K.S., Trinh, L., et al., 2008. Aerobic physical activity and resistance training: an application of the theory of planned behavior among adults with type 2 diabetes in a random, national sample of Canadians. *Int. J. Behav. Nutr. Phys. Act.* 5, 61. <http://dx.doi.org/10.1186/1479-5868-5-61>.
- Plotnikoff, R.C., Courneya, K.S., Sigal, R.J., 2010a. Alberta diabetes and physical activity trial (adapt): a randomized theory-based efficacy trial for adults with type 2 diabetes—rationale, design, recruitment, evaluation, and dissemination. *Trials* 11, 4. <http://dx.doi.org/10.1186/1745-6215-11-4>.
- Plotnikoff, R.C., Lippke, S., Courneya, K.S., et al., 2010b. Physical activity and diabetes: an application of the theory of planned behaviour to explain physical activity for type 1 and type 2 diabetes in an adult population sample. *Psychol. Health* 25 (1), 7–23. <http://dx.doi.org/10.1080/08870440802160984>.
- Plotnikoff, R.C., Trinh, L., Courneya, K., et al., 2011. Predictors of physical activity in adults with type 2 diabetes. *Am. J. Health Behav.* 35 (3), 359–370.
- Plotnikoff, R.C., Costigan, S.A., Karunamuni, N., et al., 2013a. Social cognitive theories used to explain physical activity behavior in adolescents: a systematic review and meta-analysis. *Prev. Med.* 56 (5), 245–253. <http://dx.doi.org/10.1016/j.ypmed.2013.01.013>.
- Plotnikoff, R.C., Karunamuni, N., Courneya, K., et al., 2013b. The Alberta Diabetes and Physical Activity Trial (Adapt): a randomized trial evaluating theory-based interventions to increase physical activity in adults with type 2 diabetes. [Randomized Controlled Trial Research Support, Non-U.S. Gov't]. *Ann. Behav. Med.* 45 (1), 45–56. <http://dx.doi.org/10.1007/s12160-012-9405-2>.
- Plotnikoff, R.C., Lubans, D.R., Penfold, C.M., et al., 2014a. Testing the utility of three social-cognitive models for predicting objective and self-report physical activity in adults with type 2 diabetes. *Br. J. Health Psychol.* 19 (2), 329–346. <http://dx.doi.org/10.1111/bjhp.12085>.
- Plotnikoff, R.C., Lubans, D.R., Penfold, C.M., et al., 2014b. Testing mediator variables in a physical activity intervention for women with type 2 diabetes. *Psychol. Sport Exerc.* 15 (1), 1–8. <http://dx.doi.org/10.1016/j.psychsport.2013.09.004>.
- Tabák, A.G., Herder, C., Rathmann, W., 2012. Prediabetes: A High-Risk State for Diabetes Development. *The Lancet* 379 (9833), 2279–2290. [http://dx.doi.org/10.1016/S0140-6736\(12\)60283-9](http://dx.doi.org/10.1016/S0140-6736(12)60283-9).
- von Elm, E., Altman, D.G., Egger, M., et al., 2007. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. *Prev. Med.* 45 (4), 247–251. <http://dx.doi.org/10.1016/j.ypmed.2007.08.012>.
- Wagner, J., 2011. Behavioral interventions to promote diabetes self-management. *Diabetes Spectr.* 24 (2), 61–62. <http://dx.doi.org/10.2337/diaspect.24.2.61>.
- White, K.M., Terry, D.J., Troup, C., et al., 2007. Behavioral, normative and control beliefs underlying low-fat dietary and regular physical activity behaviors for adults diagnosed with type 2 diabetes and/or cardiovascular disease. *Psychol. Health Med.* 12 (4), 485–494.
- White, K.M., Terry, D.J., Troup, C., et al., 2010. Predicting the consumption of foods low in saturated fats among people diagnosed with type 2 diabetes and cardiovascular disease. The role of planning in the theory of planned behaviour. *Appetite* 55 (2), 348–354.
- White, K.M., Terry, D.J., Troup, C., et al., 2012. An extended theory of planned behavior intervention for older adults with type 2 diabetes and cardiovascular disease. *J. Aging Phys. Act.* 20 (3), 281–299.
- Young, M.D., Plotnikoff, R.C., Collins, C.E., et al., 2014. Social cognitive theory and physical activity: a systematic review and meta-analysis. *Obes. Rev.* 15 (12), 983–995. <http://dx.doi.org/10.1111/obr.12225>.