Title: Characteristics of men classified at high-risk for type 2 diabetes mellitus using the AUSDRISK screening tool

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Abstract

Aims: The primary aim was to describe characteristics of men identified at high-risk for Type 2 Diabetes Mellitus (T2DM) using the Australian Diabetes Risk Assessment (AUSDRISK) tool. Secondary aims were to determine the prevalence of pre-diabetes and metabolic syndrome in these men. **Methods:** Men (n = 209) completed the AUSDRISK tool, with 165 identified as high-risk for T2DM (score ≥ 12, maximum 38). Demographic, anthropometric, physiological and behavioural outcomes were assessed for 101 men. Comparisons (one-way ANOVA) among three AUSDRISK score groups (12-15, 16-19, ≥ 20) were performed (significance level, $P < 0.05$). **Results:** Common risk factors (percentages) among high-risk men were waist circumference (> 90 cm; 93%), age (> 44 years; 79%), physical activity level (< 150 $min.wk^{-1}$; 59%), family history of diabetes (39%) and previously high blood glucose levels (32%). Men with AUSDRISK scores ≥ 20 had higher (mean ± SD) HbA_{1C} (6.0 ± 0.4% [42 ± 4.4 $mmol.mol^{-1}$], $P < 0.001$), FPG (5.3 ± 0.6 $mmol.L^{-1}$, $P = 0.001$) and waist circumference (113.2 ± 9.8 cm, $P = 0.026$) than men with scores of 12-15. Mean FPG for the sample was 5.0 ± 0.6 $mmol.L^{-1}$, whereas mean HbA_{1C} was 5.8 ± 0.5% [40 ± 5.5 $mmol.mol^{-1}$]. Pre-diabetes prevalence was 70% and metabolic syndrome prevalence was 62%. **Conclusions:** The AUSDRISK tool identified men who were mostly older than 44, and had large waist circumferences and elevated HbA_{1C}. These findings provide evidence supporting the usefulness of the AUSDRISK screening tool for T2DM screening in clinical and research settings.

Keywords

Type 2 diabetes mellitus; prevention; screening; fasting plasma glucose, HbA_{1C}

Abbreviations

ADA - American Diabetes Association; AES - Australian Eating Survey; ANZCTR - Australian New Zealand Clinical Trials Registry; ARFS - Australian Recommended Food Score; AUSDRISK - Australian Diabetes Risk tool; BMI - Body Mass Index; cm - centimetre; FPG - Fasting Plasma Glucose; HbA_{1C} - glycosylated haemoglobin; HOMA-IR - Homeostatic Model Assessment-Insulin Resistance; IDF - International Diabetes Federation; kg - kilograms; kJ - kilojoule; L - litre; min - minute; mIU - milli-international units; mL - millilitre; mmol - millimoles; MVPA – Moderate-Vigorous Physical Activity; n - sample size; OGTT - Oral Glucose Tolerance Test; PULSE - Prevention Using LifeStyle Education; QUICKI - Quantitative Insulin Sensitivity Check Index; SD - Standard Deviation; T2DM - Type 2 diabetes mellitus

1. Introduction

1.1 Background

Diabetes is one of the most prevalent non-communicable diseases worldwide and is estimated to reach 592 million cases (10.1%) by 2035 [1]. Type 2 diabetes mellitus (T2DM) represents approximately 90% of all diabetes cases [2]. The early identification of individuals at high-risk for T2DM allows for targeted lifestyle intervention and/or drug treatment, which may prevent or delay disease progression. This is complicated however, as T2DM, and its precursor condition pre-diabetes [3], are often asymptomatic at early stages [4], making it difficult to identify individuals who would benefit from preventive approaches. Furthermore, diagnostic tests such as fasting plasma glucose (FPG), glycosylated haemoglobin (HbA_{1C}) and an oral glucose tolerance test (OGTT) are invasive and not justified for screening purposes in terms of cost and/or time [5-7]. Consequently, many individuals with T2DM and pre-diabetes remain untreated for several years prior to clinical diagnosis [3, 4].

The use of screening tools for early detection of T2DM risk is strongly supported in the literature [8-10]. Ideal screening tools require good sensitivity (i.e., probability that the test is positive for individuals that will develop T2DM in the future) and specificity (i.e., probability that the test is negative for individuals who will not develop T2DM in the future) [9]. A number of screening tools have been validated for T2DM risk assessment, including the Finnish Diabetes Risk Score (FINDRISC) [7] and the Australian Diabetes Risk Assessment (AUSDRISK) tool [6, 11]. AUSDRISK, released in 2008, was developed using data from the large population-based AUSDIAB study [12, 13]. The tool is comprised of 10-items, assessing six modifiable and four non-modifiable risk factors. The AUSDRISK validation study [6] demonstrated good sensitivity (74%) and specificity (67.7%), with a positive T2DM predictive value of 12.7%, which is similar to the FINDRISC tool [7].

Despite the strong rationale for use, AUSDRISK is poorly used in clinical practice, predominantly due to lack of awareness of the tool [14] and of its potential usefulness. A small number of Australian studies have reported using it to assess T2DM risk in study cohorts [14-16] or as an eligibility criterion for T2DM prevention trials [17, 18]. However, no studies have reported the anthropometric and biomarker characteristics of participants identified as at high-risk for T2DM using AUSDRISK or its ability to identify individuals with elevated glycaemic markers. In addition, given the strong association between T2DM, cardiovascular disease, and several metabolic comorbidities, it is of interest to investigate the prevalence of Metabolic Syndrome (MetS) in individuals identified at high-risk for T2DM using AUSDRISK screening. Collectively, this information may provide further confidence in the usefulness of AUSDRISK screening to positively identify individuals with pre-diabetes and multiple risk factors for T2DM.

1.2 Aims

The primary aim is to profile the characteristics of a sample of Australian men identified as being at high-risk for T2DM using AUSDRISK screening (score ≥ 12 points). Secondary aims are to determine the ability of the AUSDRISK tool to: (a) identify existing pre-diabetes based on FPG and HbA_{1C} values; and (b) identify the prevalence and associated characteristics of MetS in a population of men at high-risk for T2DM.

2. Subjects, Materials and Methods

2.1 Study Design

This study is a cross-sectional investigation reporting the characteristics of Australian men (n = 101) identified with high-risk for T2DM using the AUSDRISK tool. These men were enrolled in the T2DM PULSE (Prevention Using LifeStyle Education) trial, a randomised controlled trial of a 6-month self-administered and gender-tailored lifestyle behavior change intervention (weight loss, diet modification, exercise) for men. The rationale and design of the trial are comprehensively described elsewhere [19]. AUSDRISK score was used as the primary eligibility criterion for the trial. At the baseline time point (study entry), a wide range of demographic, anthropometric, physiological and behavioural outcomes were collected. The characteristics of these men including the prevalence of pre-diabetes based on FPG and HbA_{1C} criteria [20], and the prevalence of MetS [21] were examined. Comparisons of the sample characteristics across three AUSDRISK score groups (12-15, 16-19 and ≥ 20 points) were investigated. This study was conducted at the *The University of Newcastle*, Australia and was approved by the institutions Human Research Ethics Committee. The trial is registered with the Australian New Zealand Clinical Trials Registry (ANZCTR): ACTRN12612000721808.

2.2 Participants: recruitment, eligibility and screening

To be eligible for the T2DM PULSE trial, men were required to: be aged 18-65, have a BMI 25-40 $kg.m^{-2}$ and be at high-risk for T2DM (AUSDRISK score ≥ 12 points; maximum score 38). Individuals were not required to have diagnosed pre-diabetes or markers of dysglycaemia (e.g., FPG or HbA_{1C}) in the pre-diabetes range at study entry. Individuals with diagnosed type 1 or type 2 diabetes mellitus were not eligible. Eligibility criteria did not exclude men based on their current medication regimen (e.g., medications for pre-diabetes, hypertension and dyslipidaemia) unless a particular medication was known to affect or be adversely affected by lifestyle changes and/or weight loss.

2.3 Study outcomes

Demographic information, medical history, and medication use for health conditions were obtained by an online questionnaire. In addition, several anthropometric, physiological and behavioural outcomes were assessed. Trained assessors conducted all measures following standardised protocols [19]. Repeated measurements were obtained for several outcomes (i.e., height, weight, waist circumference and blood pressure) for the purpose of accuracy. For these measures, the average of the acceptable values (within accuracy tolerance ranges) are reported.

AUSDRISK score

Men completed the 10-item AUSDRISK screening tool [6, 11] prior to study entry (< 1 month) as part of an online eligibility-screening question for the T2DM PULSE trial. The question items and scoring are presented in Table 1, along with a summary of the participants' responses. According to the AUSDRISK report [11], 7% of individuals with scores between 12-15 points (out of a possible 38 points) will develop T2DM within five years, 14% of individuals with scores between 16-19 points will develop T2DM within five years, and 33% of individuals with scores greater than 20 points will develop T2DM within

five years. Therefore, the number of men within these three AUSDRISK score groupings (12-15, 16-19 and ≥ 20 points) and their characteristics are reported.

Anthropometrics

Weight was measured to 0.01 kg on a calibrated digital scale (CH-150kp, A&D Mercury Pty Ltd., Seven Hills, NSW, Australia). Participants were weighed in light clothing and without shoes. Height (cm) was measured to 0.1 cm using the stretch stature method (without shoes) on a calibrated stadiometer (Harpenden portable stadiometer with high speed Veeder-Root counter, Holtain Ltd, Pembrokeshire, United Kingdom). Body mass index (BMI) was calculated using the equation (weight [kg]/height [m^2]) [22].

Waist circumference (cm) was measured to 0.1 cm using a non-extensible steel tape (KDSF10-02, KDS Corporation, Osaka, Japan). An assessor with Level 1 anthropometry qualifications from the *International Society for the Advancement of Kinanthropometry* conducted all measurements. Waist circumference was assessed in two places: i) at the observable narrowest point between the lower costal border and iliac crest, and ii) level with the umbilicus. Body composition was measured using bioimpedance analysis (InBody720, Biospace Co., Ltd, Seoul, Korea) to calculate body fat (%) and visceral fat area (cm^2). This device is valid and reliable for the assessment of body composition [23].

Metabolic profile

A single blood sample was collected after an overnight fast and analysed using standardised procedures by staff from a *National Association of Testing Authorities* accredited pathology service. Blood sample assays included FPG ($mmol.L^{-1}$), HbA_{1C} (% and $mmol.mol^{-1}$), insulin ($mIU.L^{-1}$), triglycerides ($mmol.L^{-1}$) and cholesterols (total, HDL,

LDL; mmol.L^{-1}). Homeostatic model of insulin resistance (HOMA-IR2) and Quantitative insulin sensitivity check index (QUICKI) were calculated from FPG and insulin values.

Cardiovascular parameters

Blood pressure was measured to 1 mmHg using a manual inflation digital sphygmomanometer (NISSEI/DS-105E, Nihon Seimitsu Sokki Co. Ltd., Gunma, Japan). A standardised procedure [24, 25] was followed requiring participants to be seated for five minutes before the first measurement, with two minutes between repeated measurements.

Physical activity

Physical activity (steps.day^{-1}) was objectively measured using pedometers (Yamax Digi-Walker SW200, Yamax Corporation, Kumamoto City, Japan). Participants were required to wear the device for seven days after their baseline assessments and to record the number of steps taken on a recording sheet at the end of each day. The average step count per day is reported.

Self-report physical activity level (min.$week^{-1}$) was assessed using a modified version [26] of the validated Godin Leisure-Time Exercise Questionnaire [27]. Participants were asked to indicate the frequency and duration of light, moderate, and vigorous intensity physical activities sessions in the past month. The average total time per week (frequency x duration) spent in moderate-vigorous physical activity (MVPA) is reported.

Dietary quality

Dietary intake and quality were assessed using the validated Australian Eating Survey (AES) [28], a 120-item semi-quantitative food frequency questionnaire with 15 supplementary questions regarding age, vitamin supplement use, food and sedentary

behaviours. The AES calculates mean daily kJ intake and nutrient composition. In addition, the AES generates an Australian recommended food score (ARFS) [29], which provides an overall indication of diet quality. The full description of the AES can be viewed elsewhere [28].

Prevalence of pre-diabetes and MetS

Objectively measured data were used to determine the prevalence of pre-diabetes and MetS. Pre-diabetes was defined using the American Diabetes Association (ADA) criteria [20] - FPG (5.6-6.9 mmol.l^{-1}) and HbA_{1C} (5.7-6.4%, 39-46 mmol.mol^{-1}). MetS was defined using the International Diabetes Federation (IDF) definition [21]. To be classified with MetS an individual must have central obesity (waist circumference ≥ 94 cm or BMI ≥ 30 kg.m^{-2}) and two of the following four criteria: elevated triglycerides (≥ 1.7 mmol.L^{-1} or specific treatment for lipid abnormality), low HDL-cholesterol (≤ 1.03 mmol.L^{-1} or specific treatment for lipid abnormality), elevated blood pressure (systolic ≥ 130 mmHg, diastolic ≥ 85 mmHg or treatment for hypertension) and elevated FPG (≥ 5.6 mmol.L^{-1}).

2.4 Statistical analyses

All statistical analyses were performed using IBM SPSS version 21. Participant responses (counts and percentages) to the AUDRISK tool are reported, as well as the number of men in each AUSDRISK score group [11] (i.e., 12-15, 16-19 and ≥ 20 points). The demographic, anthropometric, physiological and behavioural characteristics associated with each AUSDRISK group are presented as mean ± SD (primary aim). Statistical differences among the three AUSDRISK groups were tested using one-way analysis of variance (ANOVA) with post-hoc Games-Howell procedure for correction of unequal variances between groups (significance level, $P < 0.05$). The prevalence of pre-diabetes and MetS (counts and percentages) are reported based on the relevant pre-diabetes and

MetS criteria outlined previously (secondary aims a and b). In addition, the characteristics (mean ± SD) of men with MetS are presented for each of the MetS criterion, along with the percentage of men within the subsample who achieved the criterion value.

3. Results

3.1 Participants and AUSDRISK screening tool responses

The AUSDRISK screening tool was completed by 209 men, of whom 166 (79%) were classified as at high-risk for T2DM. Table 1 reports the AUSDRISK responses of men with lower (< 12) and high-risk scores (≥ 12). The sample was predominately Caucasian and most men were born in Australia (92%). Men were more likely to be classified in the high-risk group if they were: older (> 44 years), had a family history of diabetes, were taking blood pressure medication, and had a large waist circumference. All Aboriginal, Torres Straight Islander, Pacific Islander and Maori men; as well as all men who were smokers or who had previously high blood glucose levels were classified with high-risk for T2DM.

3.2 Characteristics of men at high-risk for T2DM

Of the 166 men who were screened with high-risk for T2DM, 101 met additional eligibility criteria for the T2DM PULSE trial. Demographic, anthropometric, physiological, behavioural outcomes were subsequently assessed for these men. The characteristics of men grouped by their AUSDRISK score (12-15, 16-19, ≥ 20) are summarised in Table 2 (primary aim). Forty per cent of men scored 12-15 points, 24% scored 16-19 points, and 37% scored ≥ 20 points. Strong associations were observed between higher AUSDRISK scores and T2DM risk factors. Post-hoc testing for between group differences revealed that men with AUSDRISK scores ≥ 20 points were significantly older in age ($P = 0.001$) and had larger waist circumference ($P = 0.026$), higher visceral fat area ($P = 0.013$), higher FPG ($P = 0.001$) and higher HbA_{1C} ($P < 0.001$) compared to men with lower scores (12-15). In addition, medication use for hypertension and dyslipidaemia was more commonly

reported in men with AUSDRISK scores ≥ 20 (hypertension: 59%; and dyslipidaemia: 51%), compared to men with scores of 12-15 (18% and 25%, respectively) and men with scores of 16-19 (29% and 21%, respectively). No men reported the use of medication for hyperglycaemia.

3.3 Identification of pre-diabetes

Mean ± SD FPG was 5.0 ± 0.6 mmol.L^{-1}, while mean HbA_{1C} was 5.8 ± 0.5% (40 ± 5.5 mmol.mol^{-1}). The number of men with FPG, HbA_{1C} or both FPG *and* HbA_{1C} values above the respective ADA pre-diabetes cut-points are reported in Table 3. Seventy per cent of men (n = 71) had FPG and/or HbA_{1C} values in the pre-diabetes range (secondary aim a). Only 20% of the sample had an FPG in the pre-diabetes range, whereas 65% had an HbA_{1C} in the pre-diabetes range.

3.4 Metabolic syndrome

The prevalence of MetS in the sample of men was 62% (secondary aim b). Table 4 reports the mean ± SD of objectively assessed outcomes relevant to the five criteria used to define MetS. Interestingly, elevated FPG was the least frequently achieved MetS criteria.

4. Discussion

This study provides a comprehensive examination of the characteristics of Australian men identified as at high-risk for T2DM using AUSDRISK screening. These men were predominately Caucasian, > 44 years of age, non-smokers and had elevated waist circumference. Many characteristics were similar among men in three AUSDRISK score groups (12-15, 16-19 and ≥ 20 points) groups, however men scoring ≥ 20 points had significantly higher waist circumference, visceral fat area, FPG and HbA_{1C} compared to men with scores of 12-15. Mean HbA_{1C} (5.8%, 40 mmol.mol^{-1}) was above the ADA pre-

diabetes cut-point (5.7%) [20], whereas mean FPG (5.0 mmol.L^{-1}) was substantially below the cut-point (5.6 mmol.L^{-1}). Furthermore, there was a large discrepancy in the classification of pre-diabetes based on HbA_{1C} (65%) and FPG (20%). The prevalence of pre-diabetes was 70% based on FPG and HbA_{1C} values and the prevalence of MetS was 62%. Of the five MetS criteria, elevated FPG had the lowest frequency, with only 29% of men with MetS meeting the cut-point of 5.6 mmol.L^{-1}. Given the high prevalence of existing pre-diabetes in the current sample and the elevations in multiple risk factors, it is clear that the AUSDRISK tool has good ability to positively identify Caucasian men at high-risk for T2DM. These findings provide evidence supporting the usefulness of the AUSDRISK tool for prediabetes screening for men in clinical practice and research settings.

The current study has assessed a wide range of demographic, anthropometric, physiological and behavioural outcomes in men identified at high-risk for T2DM using AUSDRISK screening. When comparing three AUDRISK score groups, we found that men with scores ≥ 20 had significantly higher BMI, waist circumference and visceral fat area than men with scores of 12-15. These men also had significantly higher mean HbA_{1C} and FPG levels compared to men with scores of 12-15. This is consistent with previous research indicating the strong association between age [2], abdominal obesity [30] and hyperglycaemia. Furthermore, we found that mean HbA_{1C} was above the pre-diabetes range only for men with AUSDRISK scores of ≥ 16 and that mean FPG was substantially lower than the pre-diabetes cut-point across all three AUSDRISK groups. This finding was particularly surprising given the aforementioned characteristics of men in the study and the fact that over a third of these men indicated on the AUSDRISK tool that they had previously had “high blood glucose”, most likely FPG, values.

Surprisingly, physical activity and dietary behaviours were markedly similar across the three AUSDRISK groups. More than half of high-risk men (59%) indicated they did not undertake the recommended level of physical activity of 150 mins.week^{-1}. No significant between group differences were observed for self-report estimates of MVPA. However, men with higher AUSDRISK scores (16-19 and ≥ 20 points) reported performing less than the recommended level of MVPA per week, whereas men with AUDRISK scores (12-15) did report achieving the recommended amount of MVPA per week. In addition, men in all three AUSDRISK groups were in the “low active” category [31] for objectively measured physical activity (pedometer steps.day^{-1}). These findings are important given the known effects of physical activity on blood glucose regulation over both acute (immediately post-exercise and up to 72 hours) and chronic time frames [32, 33]. Regarding dietary quality, 39% of high-risk men indicated they did not eat any vegetables or fruit daily. Analysis of dietary quality indicated that men across all three AUSDRISK groups scored below the suggested ARFS minimum target of 32, which is indicative of moderate quality diet and representative of consumption of a reasonable variety of nutritious foods weekly, including vegetables, fruit, wholegrains, lean meat and reduced fat dairy, and more optimal nutrient intakes in terms of lower saturated fat and higher fibre intakes [29]. Notably, previous studies investigating vegetable/fruit intake and T2DM risk have reported mixed results. A meta-analysis by Carter et al [34] reported no significant association between total vegetable or total fruit intake and incidence of T2DM. In contrast, a meta-analysis by Cooper et al [35] did report a significant association between total vegetable intake and T2DM incidence. Interestingly, both meta-analyses reported significant associations between high consumption of green leafy vegetables and reduced T2DM [34, 35]. In addition, Mursu et al [36] reported a significant association between high berry consumption and reduced T2DM risk. Further detailed analysis of dietary intake with respect to AUSDRISK score is warranted.

The characteristics of men summarised above are comparable to individuals from the AUSDIAB study, from which the AUSDRISK tool was developed. In a sub-analysis, Magliano and colleagues [13] reported the baseline characteristics of a sub-sample of individuals who developed T2DM in the following five years. Of those who returned for follow-up, 224 individuals (4%) developed T2DM. These individuals were aged (mean ± SD) 55.8 ± 12 years, with a waist circumference of 104.1 ± 11.6 cm (male value reported) and BMI of 29.3 ± 0.4 $kg.m^{-2}$. In addition, the sample was (percentages) male (51%), insufficiently active (<150 $min.wk^{-1}$ physical activity, 59%), hypertensive (55%) and had a family history of diabetes (30%). Mean HbA_{1C} was 5.5% (5.2-5.7, 25^{th}-75^{th} percentile; 37 $mmol.mol^{-1}$, 33-39) and mean FPG was 6.0 $mmol.L^{-1}$ (5.5-6.4). The characteristics of men in the current study are similar, with the exception of FPG, to the AUSDIAB sub-sample. This comparison further confirms the high-risk classification of men in the current study.

A secondary aim of this study was to report the ability of AUSDRISK to identify men with existing pre-diabetes. Analysis of fasting blood samples revealed a prevalence of pre-diabetes of 70% based on FPG and/or HbA_{1C} values. Mean HbA_{1C} was above the ADA pre-diabetes cut-point of 5.7% (39 $mmol.mol^{-1}$), whereas mean FPG was below the pre-diabetes cut-point of 5.6 $mmol.L^{-1}$. There was a large discrepancy in classification of pre-diabetes between HbA_{1C} and FPG measures. The marked observed difference may be partly explained by the different pathophysiologies involved in early stage T2DM and pre-diabetes i.e., impaired fasting glucose (IFG) or impaired glucose tolerance (IGT). Furthermore, FPG, an acute marker of glycaemia, is subject to substantial variation secondary to physical activity and/or a period of fasting prior to testing, whereas HbA_{1C} is a longer-term marker of glycaemia and is subject to less intra-individual daily variation [8]. Notably, numerous studies have demonstrated discrepancies in diagnosis of

prediabetes/T2DM using HbA_{1C}, FPG and OGTT in various populations [37-39]. This reiterates the importance of assessing HbA_{1C} in conjunction with FPG and OGTT to minimise misclassification of individuals. In summary, these findings suggest the AUSDRISK tool is sensitive in identifying individuals with elevated glycaemic markers, in particular $HbA_{1C,}$ at least in Caucasian men.

The AUSDRISK tool, in addition to identifying a sample with a high prevalence of pre-diabetes, was also successful in identifying a group of men with multiple risk factors for cardiovascular disease. Using the IDF definition [21], there was a high prevalence (62%) of MetS in the current sample of men. This was almost double the MetS prevalence (34.4%) observed for men in the population-based AUSDIAB study [40]. In those with MetS, mean waist circumference and triglyceride levels were substantially elevated above the MetS cut-point, whereas mean blood pressure was similar to the MetS cut-point. It is noteworthy that the current study sample included men who were taking medications for dyslipidaemia (19%) and hypertension (37%) and therefore the mean values for those classified with MetS must be interpreted with this in mind. In contrast to these findings, mean FPG (5.2 $mmol.L^{-1}$) in this sub-sample was considerably lower than the MetS cut-point (5.6 $mmol.L^{-1}$). This value is particularly surprising given that all men had central obesity, a risk factor strongly linked to hyperglycaemia [30].

This study has several strengths. The comprehensive set of demographic, anthropometric, physiological and behavioural outcomes has allowed for a detailed risk-profile analysis to be conducted. In particular, the inclusion of clinical biomarkers for the classification of pre-diabetes and MetS is a particular strength. This study also has some limitations. Classification of pre-diabetes was based on a single blood sample collected at the baseline time point of the T2DM PULSE trial. It was not feasible/practical to confirm blood

test results using repeat measures for diagnostic purposes. Individuals with previously unknown T2DM, but who were subsequently revealed to have FPG and/or HbA_{1C} values in the T2DM range on assessment were included in all analyses presented here. Only one participant (1%) had an FPG in the T2DM range (≥ 7.0 $mmol.L^{-1}$) and 7 participants (7%) were found to have HbA_{1C} values in the T2DM range (≥ 6.5%, 48 $mmol.mol^{-1}$). Furthermore, this study was conducted in a regional city in Australia, which has less ethnic diversity than the larger metropolitan cities. Consequently, the vast majority of the men were Caucasian and born in Australia. The limitations outlined above may influence the generalisability of the results reported in this study, however we believe these findings are important and will inform the practise of T2DM screening in clinical and research settings.

Screening for T2DM risk using AUSDRISK identified a population of men with several T2DM and MetS risk factors. Men with AUSDRISK scores ≥ 20 had higher mean waist circumference, visceral fat area, FPG levels and HbA_{1C} levels. Blood testing confirmed a high prevalence of pre-diabetes, with significantly more men in the pre-diabetes range for HbA_{1C} than FPG. In addition to risk for T2DM, the high prevalence of MetS indicates significant risk for cardiovascular disease and other obesity related co-morbidities. We conclude that the AUSDRISK screening tool is effective for the early identification of Caucasian men at high-risk for T2DM and recommend its use in clinical practice and research settings.

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6. Conflict of interest

The authors declare no conflicts of interest.

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9. Tables

Table 1. Frequency of responses for individual items of the AUSDRISK tool for men identified at high-risk (≥ 12) and those with lower risk (< 12) for type 2 diabetes mellitus

AUSDRISK question and associated score	Lower risk score (< 12) n = 43		High-risk score (≥ 12) n = 166		Total n = 209	
	n	%	n	%	n	%
Q1. Your age group						
Under 35 years (0 points)	18	42	13	8	31	15
35-44 years (2 points)	10	23	22	13	33	16
45-54 years (4 points)	6	14	48	29	54	26
55-64 years (6 points)	9	21	71	43	80	38
65 years or over (8 points)	0	0	11	7	11	5
Q2. Gender						
Male (3 points)	43	100	166	100	209	100
Q3. Ethnicity/country of birth						
a) Are you of Aboriginal, Torres Straight Islander, Pacific Islander or Maori descent?						
No (0 points)	43	100	158	95	202	97
Yes (2 points)	0	0	7	4	7	3
b) Where were you born?						
Australia (0 points)	40	93	151	91	192	92
Asia (including the Indian sub-continent), Middle East, North Africa, Southern Europe (2 points)	0	0	0	0	0	0
Other (0 points)	3	7	14	8	17	8
Q4. Have either of your parents, or any of your brothers or sisters been diagnosed with diabetes (type 1 or type 2)?						
No (0 points)	35	81	101	61	137	66
Yes (3 points)	8	19	64	39	72	34
Q5. Have you ever been found to have high blood glucose (sugar) (for example, in a health examination, during an illness)?						
No (0 points)	43	100	112	67	155	74
Yes (6 points)	0	0	53	32	54	26
Q6. Are you currently taking medication for high blood pressure?						
No (0 points)	41	95	105	63	147	70
Yes (2 points)	2	5	60	36	62	30
Q7. Do you currently smoke cigarettes or any other tobacco products on a daily basis?						
No (0 points)	43	100	156	94	200	96

Yes (2 points)	0	0	9	5	9	4
Q8. How often do you eat vegetables or fruit?						
Every day (0 points)	27	63	101	61	129	62
Not every day (1 points)	16	37	64	39	80	38
Q9. On average, would you say you do at least 2.5 hours of physical activity per week (for example, 30 minutes a day on 5 or more days a week)?						
Yes (0 points)	25	58	67	40	93	44
No (2 points)	18	42	98	59	116	56
Q10. Your waist measurement taken below the ribs (usually at the level of the navel, and while standing)						
For men of Asian or Aboriginal or Torres Straight Islander descent						
Less than 90 cm (0 points)	0	0	0	0	0	0
90-100 cm (4 points)	0	0	2	1	2	1
More than 100 cm (7 points)	0	0	5	3	5	2
For all others						
Less than 102 cm (0 points)	27	63	10	6	38	18
102-110 (4 points)	15	35	77	46	92	44
More than 110 cm (7 points)	1	2	72	43	73	35

Table 2. Characteristics of men based on AUSDRISK score groups

Characteristics	AUSDRISK Score 12-15 (n = 40)		AUSDRISK Score 16-19 (n = 24)		AUSDRISK Score ≥ 20 (n = 37)		One-way ANOVA
	Mean	SD	Mean	SD	Mean	SD	P-Value
Age (years)	47.5	10.7	55.0 *	6.7	55.8 *	8.2	< 0.001
Weight (kg)	102.20	12.0	99.25	12.71	106.37	14.00	0.101
BMI ($kg.m^{-2}$) [a]	32.2	3.3	31.8	3.4	33.0	3.5	0.414
Waist (umbilicus, cm) [b]	110.9	8.4	110.7	8.1	115.2	9.0	0.048
Waist (narrowest, cm) [b]	107.5	8.8	109.2	9.5	113.2 *	9.8	0.031
Fat mass (%) [c]	30.3	6.5	32.6	5.3	32.8	4.9	0.118
Visceral fat area (cm^2) [d]	165.7	29.8	177.1	27.4	185.9 *	30.9	0.014
Systolic BP (mmHg) [e]	124	11	128	12	129	13	0.101
Diastolic BP (mmHg) [e]	82	8	84	8	84	9	0.544
FPG ($mmol.L^{-1}$) [f]	4.8	0.6	5.0	0.6	5.3 *	0.6	0.001
HbA_{1C} (%) [g]	5.6	0.4	5.8	0.5	6.0 *	0.4	< 0.001
HbA1C $mmol.mol^{-1}$ [g]	38	4.4	40	5.5	42	4.4	< 0.001
Insulin ($mIU.L^{-1}$)	8.8	6.1	7.9	3.3	11.4	7.1	0.066
HOMA-IR2 [h]	1.1	0.8	1.0	0.4	1.5	0.9	0.052
QUICKI [i]	0.36	0.04	0.36	0.03	0.34 *	0.03	0.020
Triglycerides ($mmol.L^{-1}$) [j]	2.5	4.2	2.0	1.2	2.0	1.2	0.687
Cholesterol ($mmol.L^{-1}$) [k]	5.0	1.0	5.0	1.2	4.8	0.9	0.705
LDL-Cholesterol ($mmol.L^{-1}$) [l]	3.1	0.8	3.1	0.8	2.9	0.8	0.362
HDL-Cholesterol ($mmol.L^{-1}$) [m]	1.0	0.2	1.0	0.3	1.1	0.2	0.577
Physical activity ($steps.day^{-1}$) [n]	6927	2794	5889	1982	6528	2757	0.335
MVPA ($mins.week^{-1}$) [o]	154	200	85	126	111	154	0.261
Total Energy intake ($kj.day^{-1}$)	11192	3110	11197	3683	11672	3437	0.790
ARFS [p]	30.8	9.9	31.0	7.2	31.8	10.3	0.893
ARFS vegetables [q]	11.4	4.5	12.2	4.0	11.5	5.2	0.783
ARFS fruit [r]	4.2	3.2	3.6	2.7	4.4	2.5	0.541

* Significantly different to AUSDRISK score 12-15, P < 0.05 (post-hoc testing)
[#] Significantly different between to AUSDRISK score 16-19, P < 0.05 (post-hoc testing)

The following reference ranges for anthropometric, physiological and behavioural outcomes are associated with increased risk for T2DM, cardiovascular disease and/or generally poor health. [a] Body Mass Index (BMI) > 25 $kg.m^{-2}$ (overweight or obese) [22]. [b] waist circumference ≥ 94 cm (central obesity) [21]. [c] fat mass ≥ 27.8% (20^{th} percentile, poor body composition, men aged 50-59 years) [41]. [d] visceral fat area > 100 cm^2 (central obesity) [42]. [e] systolic blood pressure (BP) ≥ 140 mmHg and diastolic blood pressure (BP) ≥ 90 mmHg (hypertension) [43]. [f] Fasting Plasma Glucose (FPG) ≥ 5.6 $mmol.L^{-1}$ [20]. [g] Glycosylated Haemoglobin (HbA_{1C}) ≥ 5.7% [39 $mmol.mol^{-1}$] (pre-diabetes) [20]. [h] Homeostatic Model Assessment (HOMA-IR2) > 1.85 [44] (insulin resistance). [i] Quantitative insulin sensitivity check index (QUICKI) < 0.30 (insulin sensitivity) [45]. [j] Triglycerides > 1.5 $mmol.L^{-1}$ (dyslipidaemia) [46]. [k] Cholesterol > 4.0 $mmol.L^{-1}$ (dyslipidaemia) [46]. [l] LDL-C > 2.0 $mmol.L^{-1}$ (dyslipidaemia) [46]. [m] HDL-C < 1.0 $mmol.L^{-1}$ (dyslipidaemia) [46]. [n] Physical activity < 7499 steps/day (low active) [31]. [o] Moderate-Vigorous Physical Activity (MVPA) <150 $min.wk^{-1}$ (low active) [47]. [p] Australian Recommended Food Score (ARFS) < 32 points (less than ideal diet quality) [29]. [q] ARFS vegetables max score 21. [r] ARFS fruit max score 12.

Table 3. Distribution of Fasting Plasma Glucose and HbA_{1C} values above and below the pre-diabetes range

Plasma glycaemia variables used for the diagnosis of pre-diabetes [a]	**Total (n = 101)**	
	n	**%**
FPG < 5.6 $mmol.L^{-1}$	81	80
FPG ≥ 5.6 $mmol.L^{-1}$	20	20
HbA_{1C} < 5.7% (39 $mmol.mol^{-1}$)	35	35
HbA_{1C} ≥ 5.7% (39 $mmol.mol^{-1}$)	66	65
HbA_{1C} < 5.7% (39 $mmol.mol^{-1}$) & FPG < 5.6 $mmol.L^{-1}$	30	30
HbA_{1C} < 5.7% (39 $mmol.mol^{-1}$) & FPG ≥ 5.6 $mmol.L^{-1}$	5	5
HbA_{1C} ≥ 5.7% (39 $mmol.mol^{-1}$) & FPG < 5.6 $mmol.L^{-1}$	51	50
HbA_{1C} ≥ 5.7% (39 $mmol.mol^{-1}$) & FPG ≥ 5.6 $mmol.L^{-1}$	15	15

FPG – Fasting Plasma Glucose, HbA_{1C} – Glycosylated Haemoglobin

[a] Pre-diabetes is defined according to the ADA cut-points - FPG ≥ 5.6 $mmol.L^{-1}$ or HbA_{1C} ≥ 5.7% [39 $mmol.mol^{-1}$] (pre-diabetes) [20].

Table 4. Characteristics of men classified with Metabolic Syndrome (n = 63)

MetS criterion [a]	**Mean**	**SD**	**Percentage (%) of men who met the individual criteria**
Central obesity			
Waist circumference ≥ 94 cm	112	9	100
BMI ≥ 30 $kg.m^{-2}$	33	3	
Elevated triglycerides			
≥ 1.7 $mmol.L^{-1}$	2.9	3.3	75
or specific treatment for dyslipidemia			
Low HDL-cholesterol			
≤ 1.03 $mmol.L^{-1}$	0.97	0.23	68
or specific treatment for dyslipidemia			
Elevated blood pressure			
Systolic ≥ 130 mmHg	129	12	43
Diastolic ≥ 85 mmHg or treatment of previously diagnosed hypertension	85	7	60
Elevated FPG			29
≥ 5.6 $mmol.L^{-1}$	5.2	0.7	

BMI – Body Mass Index, FPG – Fasting Plasma Glucose

[a] Metabolic Syndrome is defined by central obesity (waist circumference or BMI) plus any two of the remaining four criteria.