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Special Issue

# Exploration of diet, physical activity, health knowledge and the cardiometabolic profile of young adults with intellectual disability

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## Abstract

*Background* Young adults with intellectual disability (ID) are experiencing early mortality, and it is suggested that they are living with undiagnosed cardiovascular and metabolic risk factors (hereafter referred to as *cardiometabolic*).

*Methods* We investigated the association between modifiable risk factors and cardiometabolic health profile in adults with ID aged 18–45 years through clinical evaluation of traditional cardiometabolic parameters, and assessment of physical activity levels, diet and associated health knowledge.

*Results* We found that young adults with ID have an increased obesity (mean body mass index; ID group: 32.9 ± 8.6 vs. control group: 26.2 ± 5.5, $P = 0.001$), are engaging in less physical activity than the age-matched general population (total activity minutes per week; ID group: 172.2 ± 148.9 vs. control group: 416.4 ± 277.1, $P < 0.001$), and overall have unhealthier diets. Additionally, knowledge about nutrition and physical activity appears to be an important predictor of cardiometabolic risk in this population. If young people with ID are to improve their cardiometabolic health to reduce morbidity and early mortality, we need to further explore how to consistently apply health messaging to get lasting behavioural change in this population.

**Keywords** cardiometabolic risk, intellectual disability, knowledge, nutrition, physical activity

## Introduction

People with intellectual disability (ID) face numerous health inequities, and despite increased awareness initiatives over recent decades, their health status remains poor (Emerson *et al.* 2016; Hughes-McCormack *et al.* 2018). The discrepancies in health manifest in health care access, reduced life expectancy, increased prevalence of chronic health conditions and unmet health needs (Ouellette-Kuntz 2005; O'Leary *et al.* 2018; Tyrer *et al.* 2019). Young adults with ID seem to be at high risk of having adverse health outcomes (Young-Southward

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*et al*. 2017), and recent figures indicated they are four times more likely to experience premature mortality than those without ID (Trollor *et al*. 2017). The World Health Organization (WHO) reports that cardiovascular disease (CVD) represents 31% of all deaths, with coronary heart disease and stroke being the two leading causes (World Health Organization 2009). Causes of death in people with ID are similar, with circulatory diseases determined to be one of the most common underlying sources of mortality and represent around 20% of all deaths (Hosking *et al*. 2016; Trollor *et al*. 2017; Cooper *et al*. 2020). In the general population, deaths from circulatory diseases in young adults have been falling in recent years as a result of intensive health promotion initiatives (O'Flaherty *et al*. 2012); however, the downwards trend has not been observed in people with ID, suggesting that health promotion activities are either not reaching the majority of this population (Salomon 2019) or are an ineffective standalone solution. *Health promotion* is defined as 'any planned combination of educational, political, regulatory, and organizational supports for actions and conditions of living conducive to the health of individuals, groups, or communities' (Green and Kreuter 1993) and is often used to encourage traditional methods of improving health such as diet and physical activity, also commonly referred to as *lifestyle-related* factors. However, in a health context, *lifestyle-related* factors imply that risk exposure is voluntary and a result of free choice. Instead, for the purpose of this paper, we refer to them as *modifiable* risk factors.

Cardiovascular risk factors include risk-conferring habits or behaviours, circumstances or conditions that increase a person's chance of developing CVD. According to WHO, the most common modifiable risk factors are physical activity, tobacco use, body weight and diet (World Heart Federation 2017). Other major contributors include type 2 diabetes and hypertension (Petrie *et al*. 2018). Behaviours such as tobacco smoking and alcohol abuse are minor issues in the population with ID (de Winter *et al*. 2009; Department of Health and Human Services 2015), suggesting that reduced levels of physical activity (Dairo *et al*. 2016) and poor adherence to a healthy diet (McGuire *et al*. 2007; de Winter *et al*. 2009) exert a prominent effect on cardiovascular health outcomes for this group. Reduced physical activity (Blair *et al*. 1984), a diet high in salt (Stamler 1997), saturated fat (Stamler *et al*. 1996) or sugar (Brown *et al*. 2011), and excess adiposity (Stamler 1991) are known to directly and indirectly cause blood pressure (BP) elevation and subsequently contribute to development of CVD. Additionally, the metabolic abnormalities underlying type 2 diabetes may occur as the result of overweight and/or obesity, which in itself predisposes to elevated BP and increased risk of life-threatening CVD (Meigs *et al*. 2006).

Obesity is an increasing health issue in Western societies and is a particular concern for populations such as those living with ID. Prevalence of obesity ranges from 21% to 35% (Emerson 2005; Yamaki 2005; Bhaumik *et al*. 2008; de Winter *et al*. 2012) and is higher than the general population in all age groups. Young adults with ID had double the rates of obesity than the general population (Yamaki 2005; Department of Health and Human Services 2015). This is likely due to a multitude of factors including biological determinants (Bertapelli *et al*. 2016; Krause *et al*. 2016), health-related behaviours, environment and other factors (Rimmer *et al*. 1995; de Winter *et al*. 2012). Health literacy has been shown to be less accessible for people living with disabilities; thus, whilst many adults without ID will be familiar with the concepts of nutrition and physical activity contributing to health, this messaging may not have reached people with different communication needs. Reduced knowledge and/or understanding of the potential health risks of inadequate or excessive nutritional intake and low levels of physical activity is among the potential determinants in the aetiology of obesity, and other non-communicable diseases, in young adults with ID.

With evidence of CVD morbidity and early mortality in this population, an insight into the associated risk factors is crucial for detecting and preventing progression of cardiometabolic disease in young people with ID. Recent studies in this cohort have revealed that young adults with ID demonstrate an increased prevalence of subclinical and environmental factors (Zwack *et al*. 2021) related to CVD development. To further develop a clear understanding of their cardiometabolic profile, this exploratory study aims to determine the prevalence of modifiable risk factors, such as physical activity, diet and associated health knowledge in adults with ID aged 18–45 years.

## Methods

### Study population

Two groups of participants aged 18–45 years were recruited for this study: a cohort with ID ($n$ = 39) and a control group without ID ($n$ = 29). Inclusion criteria for the cohort with ID included (1) a diagnosis of intellectual disability according to the Diagnostic and Statistical Manual of Mental Disorders - 5th Edition (DSM-5) (American Psychiatric Association 2013) (2) are 18 to 45 years of age inclusive; and (3) reside in Victoria, Australia. Participants with ID were recruited through disability organisations in Victoria, Australia. They were provided with an information sheet in plain English outlining the purpose of the research and the data collection process. Participants were enrolled in the ID group after giving their informed consent to participate, or a proxy gave consent on their behalf. Investigators followed a strict and robust process for gaining informed consent; a checklist was used to ensure that investigators were able to make a distinction between participants who were able to provide their consent, or whether a proxy was required to provide consent on the participant's behalf. Age-matched adults without ID living in Victoria were recruited from the general community to participate in the control group, through distribution of flyers and online advertisements. Families and caregivers of participants with ID were also invited to participate as controls ($n$ = 5). The Swinburne University of Technology ethics committee approved the study (SHR Project 2018/236).

Level of support was classified as least supported (residing independently), moderately supported (residing in an independent living facility or at home with parents/carer) or most supported (residing in a high dependency unit, or with a high level of support provided), using DSM-5 criteria. The severity of ID was classified as mild, moderate, severe or profound, and was determined using carer-report of severity and was substantiated using DSM-5 criteria by a trained clinician with classifications based on daily skills and intensity of support needed (Boat and Wu 2015). Aetiology of ID, postcode of residence, place of education or employment, medical history, medications, smoking status and level of alcohol consumption were obtained through semi-structured interview-style questioning of the participant and/or their proxy.

*Power estimate*

A statistician (A. T.) completed a power estimate using data from a study measuring traditional and subclinical CVD risk parameters in young, overweight adult males (Lambert *et al.* 2017). It was determined that to see a statistically significant difference in cardiovascular parameters between the ID group and control group, a minimum sample size of $n$ = 23 would be sufficient.

### Clinical assessment

*Physical activity level*

Physical activity was assessed by interview with participants and/or their proxy providing a seven-day recall of their physical activity levels. This was inclusive of incidental activity (e.g. walking to the bus), organised activity (e.g. gym class, soccer practise) or activities of daily living (e.g. housework, gardening). The intensity of the activity was classified as either low, moderate or high using alternative language such as 'easy', 'somewhat hard' and 'very hard', respectively. Participants and/or their proxy estimated the number of minutes spent on each activity. Additionally, a simple self-rating of activity level at the place or work, education or day programme was also obtained using a numeric rating scale (0–10) with 0 = little/no activity (sitting, sedentary), 5 = moderately active (on feet, standing/walking) or 10 = highly active (labouring etc.).

*Cardiovascular and metabolic measurements*

Clinic BP was measured according to the guidelines for the diagnosis and management of hypertension in adults (National Heart Foundation of Australia 2016). After 5 min of rest, BP was taken using an Omron sphygmometer (model HEM-7121) in an upright seated position. Three consecutive measurements were taken from the same arm. If there were substantial variations in the first three readings, additional measurements were taken.

Body weight was measured in lightweight clothing (shoes removed) using a digital scale. Height was measured without shoes using a stadiometer. Body mass index (BMI) was calculated as weight in kilograms divided by height in squared meters. Waist circumference was measured at the midpoint between

the lowest rib and iliac crest, and hip circumference at the level of the greater trochanters. Rate pressure product (RPP) was calculated by multiplying SBP and HR. Rate Pressure Product >9500 mmHg × bpm was classified as 'high' (Inoue *et al.* 2012). Fasting blood samples were drawn from a cannula placed in an antecubital vein for biochemical analysis of lipid profile, glucose, insulin, high-sensitivity C-reactive protein (hsCRP) and haemoglobin A1c (HbA1c).

### *Food Choice Questionnaire (modified Dietary Quality Tool)*

The Dietary Quality Tool (DQT) is a validated tool which is used to assess an individual's overall dietary quality (O'Reilly and McCann 2012). It contains 13 questions asking about current diet and the frequency in which they consume some selected foods. In order for the tool to be accessible for person's with ID, the tool was modified by the investigators under the guidance of a qualified dietician, as well as people who regularly work with this population. Modifications include questions in plain English with accompanying images and replacement of the multiple choice answers with a Likert scale for enhanced clinical utility in a population of adults with ID. The adapted version was validated in a population of adults without ID ($n$ = 35).

Each question included a 4-point Likert scale (no; yes, sometimes; yes, often; yes, every day, scoring 0–3 points). The scale was scored out of 39 points, with a higher score indicating a diversified, balanced and healthy diet.

### *Nutrition and Activity Knowledge Scale*

The Nutrition and Activity Knowledge Scale (NAKS) (Illingworth *et al.* 2003) is a validated tool used to assess the levels of nutritional and physical activity knowledge among people with an ID. We utilised the shortened version and included conversion to easy-read format in order to increase clinical utility in a population of adults with ID. Previously shortened versions have shown good construct validity (Maïano *et al.* 2010) and reliability (Sisirak *et al.* 2005). There are three multiple-choice questions per page, with each answer accompanied by a coloured image.

The scale was divided into three subscales by grouping the questions into the following themes: (1) knowledge of nutritional components of food ('*Nutrition*'), (2) healthiest/best choice ('*Healthiest choice*') and (3) knowledge about energy requirements and weight loss ('*Energy*'). The scale was scored out of 16 points, with a higher score indicating increased knowledge about nutrition and physical activity.

### *Procedure*

All participants ($n$ = 68) underwent a standardised physical assessment, performed by the same investigator (C. Z.), with assistance from two other investigators (E. L. and A. C.). Blood sample analysis was completed by an external pathology laboratory.

Both questionnaires were self-report administered by interview by the same investigator (C. Z.). The investigator was an experienced clinician and familiar with the scale. Subjects were accompanied by their carer if available. The investigator re-framed the question if the subject required clarification and verified whether the subject understood the question with prompts such as 'Tell me more about that' to ensure that unreliable responses were detected and scored accurately. Participants were closely observed for any signs of distress during delivery of both questionnaires. Subjects with a severe-profound disability ($n$ = 3) were not required to complete the NAKS as it is not validated for use in this subgroup. However, their carer was asked to complete the FCQ and self-reported activity levels on behalf of the subject.

All data were collected in real-time between December 2018 and end of February 2020.

### *Health report*

All participants were provided with a personalised health report in plain English approximately 2 weeks after the assessment session. The report provided details about the individuals BP, BMI, lipid profile and fasting blood glucose. Participants and/or their proxy were informed that the report was not diagnostic; however, parameters outside of the normal range were flagged, and the participant was urged to take the report to their General Practitioner for follow-up.

### *Statistical analysis*

To identify the differences in physical activity level, questionnaires scores, and demographic and

**Table 1** Participant demographics and between groups comparison of cardiometabolic parameters

| | ID (*n* = 39) | Control (*n* = 29) | *P*-value |
|---|---|---|---|
| **a. Age, sex, BMI, waist circumference, smoking status, alcohol consumption, physical activity levels, level of activity during the day and physiological parameters** | | | |
| Age, years | 31.5 ± 6.6 | 30.3 ± 6.0 | 0.481 |
| Male/female | 29/10 | 15/14 | |
| BMI, kg/m$^2$ | 32.9 ± 8.6 | 26.2 ± 5.5 | **0.001** |
| BMI normal/overweight/obese | 9/6/24 | 16/5/7 | |
| Waist circumference (cm) | 106.7 ± 21.2 | 88.8 ± 17.2 | **0.001** |
| Current smoker/non-smoker† | 2/37 | 2/27 | 0.093 |
| Consumes alcohol/abstains† | 16/23 | 23/6 | **0.001** |
| Consumes alcohol (%) | 41.0% | 79.3% | |
| Psychotropic medication use, *n* | 10 | 1 | |
| *Physical activity levels* | | | |
| Low intensity, min/week | 77.8 ± 163.5 | 101.9 ± 163.4 | 0.440 |
| Moderate intensity, min/week | 73.6 ± 118.6 | 225.0 ± 253.2 | **0.006** |
| High intensity, min/week | 21.5 ± 70.9 | 89.5 ± 175.4 | **0.017** |
| Total activity, min/week | 172.2 ± 148.9 | 416.4 ± 277.1 | <**0.001** |
| Meeting minimum recommended activity levels (%)* | 30.7% | 65.5% | |
| Daily self-rating of activity levels (0–10) | 3.9 ± 2.9 | 4.1 ± 2.7 | 0.767 |
| *Physiological parameters* | | | |
| SBP, mmHg | 127 ± 13 | 122 ± 13 | 0.129 |
| DBP, mmHg | 82 ± 10 | 77 ± 8 | 0.054 |
| Resting HR, bpm | 81 ± 12 | 73 ± 6 | **0.002** |
| RPP | 10 391 ± 2284 | 8944 ± 1407 | **0.004** |
| Fasting glucose, mmol/L | 4.6 ± 0.8 | 4.6 ± 0.5 | 0.984 |
| Insulin, mU/L | 13.3 ± 9.4 | 8.6 ± 4.1 | **0.026** |
| Hba1c, mmol/mol | 35.1 ± 5.1 | 30.3 ± 3.9 | **0.001** |
| hsCRP, mg/L | 6.8 ± 9.8 | 2.3 ± 5.8 | 0.052 |
| Total cholesterol, mmol/L | 4.6 ± 0.9 | 4.8 ± 1.0 | 0.310 |
| HDL cholesterol, mmol/L | 1.3 ± 0.4 | 1.4 ± 0.3 | 0.195 |
| LDL cholesterol, mmol/L | 2.7 ± 0.8 | 2.9 ± 0.9 | 0.274 |
| Non-HDL cholesterol, mmol/L | 3.2 ± 0.8 | 3.4 ± 1.0 | 0.369 |
| Triglycerides, mmol/L | 1.3 ± 0.6 | 1.1 ± 0.5 | 0.123 |

| | ID no medication (*n* = 29) | ID using psychotropics (*n* = 10) | *P*-value |
|---|---|---|---|
| **b. Demographics, physical activty levels and physiological parameters for subjects with ID who use and do not use psychotropic medications.** | | | |
| Age, years | 32.1 ± 6.9 | 29.7 ± 5.9 | 0.309 |
| Male/female† | 22/7 | 7/3 | |
| BMI, kg/m$^2$ | 33.2 ± 8.9 | 32.0 ± 8.6 | 0.708 |
| Waist circumference (cm) | 107.1 ± 20.3 | 105.8 ± 25.3 | 0.885 |
| Total activity, min/week | 172.2 ± 163.0 | 159.0 ± 115.0 | 0.712 |
| SBP, mmHg | 127.8 ± 14.8 | 125.6 ± 12.6 | 0.650 |
| DBP, mmHg | 82.7 ± 12.0 | 82.7 ± 7.8 | 0.995 |
| Resting HR, bpm | 79.5 ± 11.3 | 85.9 ± 14 | 0.218 |
| Fasting glucose, mmol/L | 4.7 ± 1.0 | 4.4 ± 0.5 | 0.366 |
| Insulin, mU/L | 13.3 ± 10.9 | 13.3 ± 5.4 | 0.986 |

**Table 1.** *(Continued)*

| | ID no medication (*n* = 29) | ID using psychotropics (*n* = 10) | *P*-value |
|---|---|---|---|
| **b. Demographics, physical activty levels and physiological parameters for subjects with ID who use and do not use psychotropic medications.** | | | |
| Hba1c, mmol/mol | 35.9 ± 5.1 | 33.0 ± 5.1 | 0.195 |
| hsCRP, mg/L | 6.9 ± 10.8 | 6.4 ± 7.9 | 0.893 |
| Total cholesterol, mmol/L | 4.7 ± 0.9 | 4.3 ± 0.9 | 0.361 |
| HDL cholesterol, mmol/L | 1.3 ± 0.4 | 1.1 ± 0.2 | 0.136 |
| LDL cholesterol, mmol/L | 0.8 ± 3.2 | 0.8 ± 3.1 | 0.635 |
| Non-HDL cholesterol, mmol/L | 0.8 ± 1.3 | 1.0 ± 1.2 | 0.765 |
| Triglycerides, mmol/L | 1.3 ± 0.6 | 1.2 ± 0.5 | 0.598 |

BP, blood pressure; HR, heart rate; RPP, rate pressure product; Hba1c, haemoglobin A1c; hsCRP, high sensitivity C-reactive protein.

The *P*-values are derived from one-way analysis of variance. Bold values indicate statistical significance. Data are reported as mean ± SD.

*According to Australia's Physical Activity and Sedentary Behaviour Guidelines for adults (18–64 years) (Australian Government Department of Health 2014a).

†$\chi^2$ test.

cardiometabolic profiles between the study group with ID and the control group, *t*-tests and the $\chi^2$ test were performed. Multiple regression analysis was then undertaken to investigate the influence of subject characteristics and cardiometabolic parameters (including blood pressure, metabolic parameters and laboratory biochemistry) on nutrition and physical activity-related variables. Parameters selected for the regression analysis were determined by completing correlation matrices to assess for significant associations. These included age, sex, and anthropometric, biochemical and haemodynamic parameters. All statistical analyses were performed using R, version 4.0.3 (2020-10-10), and a *P*-value of less than or equal to 0.05 was deemed significant.

## Results

### Participant characteristics

Within the ID group, 43% had a mild disability, 49% had a moderate disability and 8% had a severe or profound disability. One subject in the ID group required ambulatory support and used a wheelchair on occasion. Postcodes of residence indicated that 25% of subjects with ID lived in urban areas and 75% resided in regional Victoria. Forty-three per cent indicated that they attend a centre-based day programme, and the remaining 57% were employed as factory workers within a Business Enterprise run by a disability organisation. Two subjects in the ID group reported a current cardiovascular condition (1. mild congestive heart failure managed with furosemide; 2. unmedicated labile hypertension), and two participants reported a congenital heart defect (1. unmedicated atrial septal defect; 2. mitral regurgitation managed with aspirin). Within the ID group, 22 participants reported intellectual disability without a known cause, nine reported having Down syndrome, six had ID in combination with autism, one participant had ID in combination with cerebral palsy, and one had a rare syndromic cause of ID.

Table 1 presents characteristics of the study population. Two participants in the ID group and two in the control group identified as current smokers. Six participants in the control group reported a history of smoking, however, classified themselves as non-smokers at the time of data collection. Approximately 40% of subjects in the ID groups reported that they consumed alcohol (either daily or weekly), compared with 80% in the control group. One participant in the control group and 10 in the ID group reporting using at least one psychotropic medication daily. Aside from the one subject with ID using a diuretic (aforementioned), no other participants in either group reported using cardiovascular agents (antihypertensives, statins etc.).

## Physiological parameters

Table 1 presents the means and SDs of the physiological parameters for the two groups. The ID group demonstrated significantly increased BMI compared with controls (ID: 32.9 ± 8.6 vs. control: 26.2 ± 5.5, $P = 0.001$). Within this ID group, 15% were overweight and 61% were obese, compared with 17% overweight and 24% obese in the group without ID (as measured by BMI). Further evidence of the extent of obesity was demonstrated by significantly increased abdominal circumference in the ID group (ID: 106.7 ± 21.2 vs. control: 88.8 ± 17.2, $P = 0.001$). Subjects with ID also showed significantly increased resting HR (ID: 81 ± 12 vs. control: 73 ± 6, $P = 0.002$), RPP (ID: 10391 ± 2284 vs. 8944 ± 1407, $P = 0.004$), Hba1c levels (ID: 35.1 ± 5.1 vs. control: 30.3 ± 3.9, $P = 0.001$), and insulin (ID: 13.3 ± 9.4 vs. 8.6 ± 4.1, $P = 0.026$); however, all other parameters did not differ to the control group.

A within group analysis (Table 1b) showed no significant differences between ID subjects who were taking psychotropic medication and subjects who were not taking this class of drug. Correlations between cardiometabolic parameters and participants using psychotropic medication is presented in the supporting information (Figures S2–S6).

## Physical activity levels

Subjects in the ID group were on average less active than the control group, with significantly lower physical activity minutes per week (Table 1, ID: 172.2 ± 148.9 vs. control: 416.4 ± 277.1, $P < 0.001$). This was also shown when the intensity of physical activity was analysed, with the ID group demonstrating significantly reduced moderate and vigorous intensity active minutes compared with the control group. There were no differences between groups in the low-intensity subcategory. Additionally,

**Table 2** Regression results for physical activity minutes

| | Estimate | Std. Error | t-value | P-value |
|---|---|---|---|---|
| a. Multiple regression analysis models for total Physical Activity minutes (per week) | | | | |
| (Intercept) | | | | |
| Age, years | −3.372 | 4.825 | −0.699 | 0.489 |
| Male sex | 143.701 | 69.269 | 2.075 | **0.045** |
| Waist-hip ratio | −449.141 | 340.211 | −1.32 | 0.195 |
| Urban postcode | 92.527 | 68.941 | 1.342 | 0.187 |
| Mild ID | −129.1 | 82.157 | −1.571 | 0.124 |
| Moderate ID | −196.44 | 77.625 | −2.531 | **0.016** |
| Physical activity frequency (>3 sessions per week) | 147.28 | 55.942 | 2.633 | **0.012** |
| DBP, mmHg | −1.604 | 2.808 | −0.571 | 0.571 |
| Insulin | −5.226 | 3.784 | −1.381 | 0.175 |
| Adjusted $R^2$: 0.394 | | | | |
| b. Multiple regression analysis models for total Physical Activity minutes (per week) excluding participants with known CVD ($n = 4$) | | | | |
| (Intercept) | | | | |
| Age, years | −4.295 | 5.089 | −0.844 | 0.404 |
| Male sex | 144.617 | 75.447 | 1.917 | 0.063 |
| Waist-hip ratio | −577.499 | 394.438 | −1.464 | 0.152 |
| Urban postcode | 92.527 | 68.941 | 1.342 | 0.187 |
| Mild ID | −115.733 | 89.357 | −1.295 | 0.204 |
| Moderate ID | −205.792 | 83.915 | −2.452 | **0.019** |
| Physical activity frequency (>3 sessions per week) | 142.576 | 60.619 | 2.352 | **0.024** |
| DBP, mmHg | −0.230 | 3.228 | −0.071 | 0.944 |
| Insulin | −5.082 | 4.029 | −1.261 | 0.215 |
| Adjusted $R^2$: 0.3867 | | | | |

BP, blood pressure; ID, intellectual disability.
Bold values indicate statistical significance.

daily self-rating of activity level in place of work or education did not differ between subjects with and without ID. According to Australia's Physical Activity and Sedentary Behaviour Guidelines for adults (Australian Government Department of Health 2014a), only 30% of the group with ID, compared with 65% of the group without ID, are meeting the minimal requirements.

Multiple regression analysis indicated that the reduced physical activity level was significantly related to moderate ID and frequency of physical activity sessions per week (Table 2a; β = −196.44, $P$ = 0.016 and β = 147.28, $P$ = 0.012, respectively). Repeat analysis excluding the participants in the ID group with known CVD ($n$ = 4), shows that these two variables remained significant predictors of physical activity levels (Table 2b; β = −205.792, $P$ = 0.019 and β = 142.576, $P$ = 0.024, respectively). The amount of physical activity minutes per week was negatively, and significantly, correlated to BMI ($r$ = −0.25, $P$ = 0.030), waist circumference ($r$ = −0.29, $P$ = 0.018), resting HR ($r$ = −0.31, $P$ = 0.009), and plasma Hba1c levels ($r$ = −0.40, $P$ = 0.003) (Fig. 1a–d).

## Nutrition and physical activity knowledge and food choices

Scores related to the NAKS and FCQ are presented in Table 3. The ID group demonstrated significantly reduced knowledge regarding nutrition and physical activity (NAKS score $P$ = 0.019) and had poorer diets (FCQ score $P$ = 0.023) compared with the control group. Subjects with ID were lacking knowledge about the nutritional components of food, energy requirements and weight loss. Overall, however, they indicated a similar knowledge to the general population when selecting the healthiest (or 'best') choice of foods to include in their diet. Severity of intellectual impairment was associated with reduced

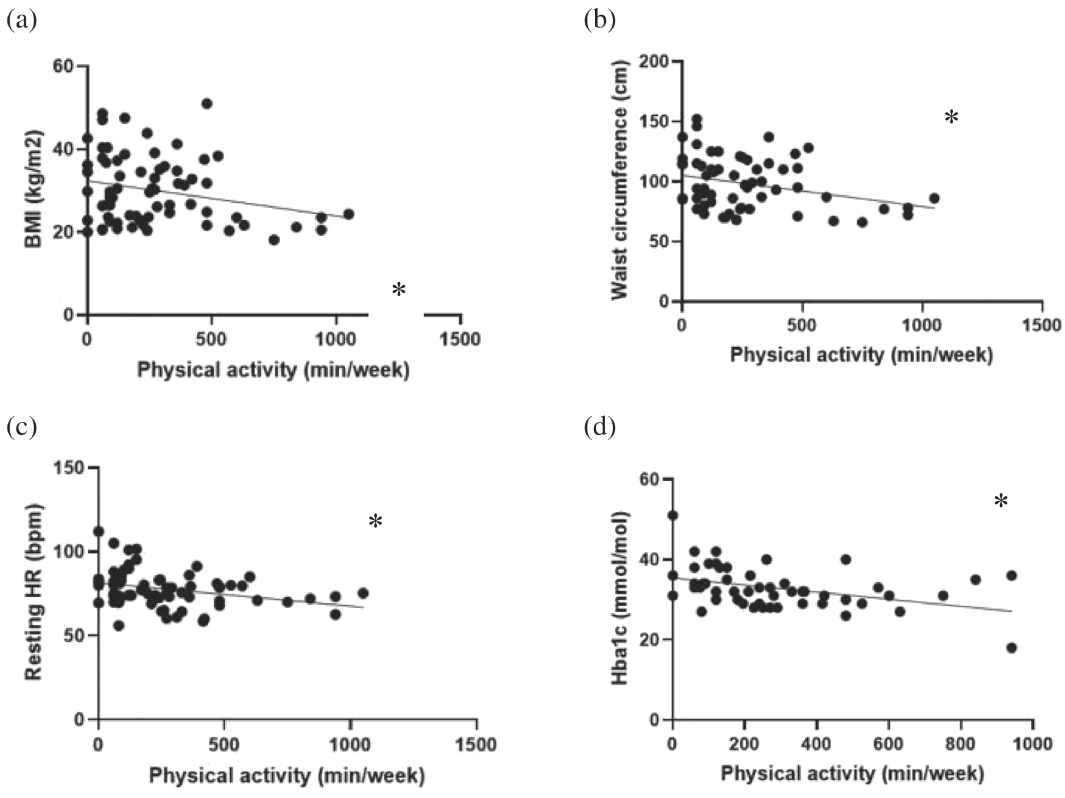


**Figure 1.** Description of FIGURES: (a) correlation between total physical activity and BMI; (b) correlation between total physical activity and waist circumference; (c) Correlation between total physical activity and resting HR; (d) correlation between total physical activity and plasma Hba1c levels. Asterisk (*) indicates statistical significance.

**Table 3** Comparison of Nutrition and Activity Knowledge and Food Choice Questionnaire scores

| | ID ($n$ = 36) | ID severity | | Controls ($n$ = 29) | $P$-value ID/ Control |
|---|---|---|---|---|---|
| | | Mild ($n$ = 17) | Moderate ($n$ = 19) | | |
| *Nutrition and Activity Knowledge Scale* | | | | | |
| Total (out of 16) | 14.0 (4.0) | 14.7 ± 1.8 | 13.1 ± 2.1† | 16 (1.0) | **0.019** |
| Nutrition | 5.0 (2.3) | 5.2 ± 1.0 | 4.3 ± 1.3† | 6.0 (0.0) | **0.002** |
| Healthiest choice | 7.0 (1.0) | 7.0 (0.0) | 6.0 ± 1.0† | 7.0 (1.0) | 0.344 |
| Energy | 3.0 (1.0) | 3.0 (0.0) | 3.0 ± 1.0 | 3.0 (0.0) | **0.009** |
| | **ID ($n$ = 39)** | **ID severity** | | **Controls ($n$ = 29)** | |
| | | **Mild ($n$ = 17)** | **Moderate-profound ($n$ = 22)** | | |
| *Food Choice Questionnaire* | | | | | |
| Total (out of 36) | 21.9 ± 4.4 | 20.4 ± 4.3 | 23.3 ± 4.1† | 24.2 ± 3.5 | **0.023** |

Data are reported as mean ± SD for variables with a normal distribution or median (interquartile range) for variables with skewed distributions. The $P$-values are derived from one-way analysis of variance. Bold values indicate statistical significance.

†Significance of mild severity versus moderate severity of ID.

knowledge; subjects with a moderate impairment scored lower in the NAKS and FCQ compared with the subjects with a mild impairment. They also scored significantly lower in two of the NAKS subscales, *nutrition* knowledge and *healthiest choice*.

The total NAKS score did not differ between urban or regional postcode, level of social support, or whether they attended a day programme or were employed as a factory worker (Table 4). This was similar for the FCQ; however, subjects who were living most independently had poorer diets than those who received more social support [median (IQR) least supported: 18.5 (3.7) vs. moderately supported: 22.7 (4.2), $P$ = 0.026].

**Table 4** Postcode, level of support and place of work or education

| ID group | (NAKS: $n$ = 36, FCQ: $n$ = 39) | | $P$-value |
|---|---|---|---|
| | *Urban postcode* | *Regional postcode* | |
| NAKS | 13.3 (2.3) | 14.9 (2.0) | 0.423 |
| FCQ | 24.3 (4.8) | 21.1 (4.0) | 0.104 |
| | *Least supported* | *Moderately supported* | |
| NAKS | 14.5 (1.9) | 13.7 (2.2) | 0.329 |
| FCQ | 18.5 (3.7) | 22.7 (4.2) | **0.026** |
| | *Day program* | *Factory worker* | |
| NAKS | 13.3 (2.4) | 14.2 (1.9) | 0.218 |
| FCQ | 23.2 (4.7) | 21.0 (4.0) | 0.147 |

NAKS, Nutrition and Activity Knowledge Survey; FCQ, Food Choice Questionnaire.

Data are reported as median (interquartile range). Bold values indicate statistical significance.

Multiple regression analysis with all participants, presented in Table 5a, showed that those who total NAKS score significantly predicted participants with ID (β = −1.680, $P$ = 0.015), Hba1c levels (β = 0.137, $P$ = 0.029), waist circumference (β = 0.030, $P$ = 0.034), and fasting glucose levels (β = −1.426, $P$ = 0.004). Each subscale showed slightly different relationships with physiological parameters. The *nutrition* subscale was related to body weight (β = 0.014, $P$ = 0.024), subjects with ID (β = −1.353, $P < 0.001$) and fasting glucose (β = −0.728, $P$ = 0.012); *healthiest choice* was negatively associated with participant age (β = −0.044, $P$ = 0.033) and vigorous-intensity physical activity (β = −0.001, $P$ = 0.042), and positively associated with Hba1c levels (β = 0.094, $P$ = 0.003); and the *energy* subscale significantly predicted BMI (β = 0.024, $P < 0.001$), participant age (β = 0.016, $P$ = 0.015) and people with ID (β = −0.332, $P$ = 0.001). When including only ID participants in the multiple regression model (Table 6), the NAKS total score was significantly, and negatively, related to participants with a moderate impairment (β = −127.929, $P$ = 0.008), insulin levels (β = −5.543, $P$ = 0.027) and DBP

**Table 5** Multiple regression analysis models for NAKS total score and subscale scores for all participants ($n$ = 65)

| | Estimate | Std. Error | t-value | P-value |
|---|---|---|---|---|
| *NAKS (total score)* | | | | |
| (Intercept) | 18.955 | 2.583 | 7.339 | **<0.001** |
| Age, years | −0.016 | 0.041 | −0.402 | 0.690 |
| Male sex | −0.388 | 0.556 | −0.698 | 0.490 |
| Waist circumference, cm | 0.030 | 0.014 | 2.202 | **0.034** |
| ID diagnosis | −1.680 | 0.658 | −2.555 | **0.015** |
| Resting HR, bpm | −0.046 | 0.024 | −1.897 | 0.066 |
| Fasting glucose, mmol/L | −1.426 | 0.459 | −3.11 | **0.004** |
| Hba1c, mmol/mol | 0.137 | 0.060 | 2.266 | **0.029** |
| Adjusted $R^2$: 0.218 | | | | |
| *Nutrition (subscale)* | | | | |
| (Intercept) | 7.655 | 1.878 | 4.075 | **<0.001** |
| Age, years | 0.044 | 0.023 | 1.853 | 0.071 |
| Male sex | −0.426 | 0.352 | −1.208 | 0.233 |
| Weight, kg | 0.014 | 0.006 | 2.333 | **0.024** |
| ID diagnosis | −1.353 | 0.353 | −3.833 | **<0.001** |
| Resting HR, bpm | −0.024 | 0.014 | −1.723 | 0.092 |
| Fasting glucose, mmol/L | −0.728 | 0.278 | −2.616 | **0.012** |
| Hba1c, mmol/mol | 0.064 | 0.037 | 1.738 | 0.089 |
| HDL cholesterol | −0.70717 | 0.53963 | −1.31 | 0.197 |
| Adjusted $R^2$: 0.277 | | | | |
| *Healthiest choice (subscale)* | | | | |
| (Intercept) | 8.778 | 1.093 | 8.026 | **<0.001** |
| Age, years | −0.044 | 0.019 | −2.216 | **0.033** |
| Male sex | 0.019 | 0.277 | 0.07 | 0.944 |
| Waist circumference, cm | 0.014 | 0.007 | 2.027 | 0.051 |
| ID diagnosis | −0.623 | 0.325 | −1.918 | 0.064 |
| DBP, mmHg | −0.025 | 0.014 | −1.845 | 0.074 |
| Fasting glucose, mmol/L | −0.438 | 0.222 | −1.974 | 0.057 |
| Hba1c, mmol/mol | 0.094 | 0.030 | 3.158 | **0.003** |
| Non-HDL cholesterol | −0.254 | 0.152 | −1.672 | 0.104 |
| High intensity physical activity | −0.001 | <0.001 | −2.112 | **0.042** |
| Adjusted $R^2$: 0.324 | | | | |
| *Energy (subscale)* | | | | |
| (Intercept) | 2.862 | 0.408 | 7.015 | **<0.001** |
| Age, years | 0.016 | 0.006 | 2.528 | **0.015** |
| Male sex | −0.114 | 0.092 | −1.227 | 0.226 |
| BMI | 0.024 | 0.006 | 3.894 | **<0.001** |
| ID diagnosis | −0.332 | 0.094 | −3.52 | **0.001** |
| SBP, mmHg | −0.004 | 0.003 | −1.317 | 0.194 |
| Fasting glucose, mmol/L | −0.097 | 0.068 | −1.437 | 0.157 |
| Non-HDL cholesterol | −0.009 | 0.046 | −0.203 | 0.839 |
| Adjusted $R^2$: 0.380 | | | | |

BP, blood pressure; ID, intellectual disability; Hba1c, haemoglobin A1c; HDL, high density lipoprotein.
Bold values indicate statistical significance.

**Table 6** Multiple regression analysis models for NAKS total score for the ID group ($n$ = 36)

| | Estimate | Std. Error | t-value | P-value |
|---|---|---|---|---|
| (Intercept) | 496.467 | 194.505 | 2.552 | **0.019** |
| Age, years | 2.005 | 3.503 | 0.573 | 0.574 |
| Male sex | 92.830 | 50.326 | 1.845 | 0.081 |
| BMI, kg/m$^2$ | 1.639 | 2.478 | 0.662 | 0.516 |
| Moderate ID | −127.929 | 43.421 | −2.946 | **0.008** |
| Urban postcode | 159.201 | 51.718 | 3.078 | **0.006** |
| Physical activity, min | 29.827 | 48.941 | 0.609 | 0.549 |
| DBP, mmHg | −4.957 | 2.128 | −2.329 | **0.031** |
| Insulin, mU/L | −5.543 | 2.307 | −2.403 | **0.027** |
| Adjusted $R^2$: 0.463 | | | | |

DBP, diastolic blood pressure; ID, intellectual disability.
Bold values indicate statistical significance.

**Table 7** Multiple regression analysis models for FCQ total score for all participants ($n$ = 68)

| | Estimate | Std. Error | t-value | p-value |
|---|---|---|---|---|
| (Intercept) | 2.790 | 0.449 | 6.209 | **<0.001** |
| Age, years | 0.014 | 0.007 | 2.069 | **0.045** |
| Male sex | −0.132 | 0.099 | −1.332 | 0.190 |
| BMI, kg/m$^2$ | 0.026 | 0.006 | 3.848 | **<0.001** |
| ID severity | −0.375 | 0.104 | −3.604 | **<0.001** |
| SBP, mmHg | −0.005 | 0.003 | −1.639 | 0.109 |
| Fasting glucose, mmol/L | −0.129 | 0.073 | −1.749 | 0.088 |
| Hba1c, mmol/mol | 0.014 | 0.010 | 1.409 | 0.167 |
| Non-HDL cholesterol, mmol/L | −0.012 | 0.053 | −0.241 | 0.810 |

BP, blood pressure; ID, intellectual disability; Hba1c, haemoglobin A1c.
Bold values indicate statistical significance.

(β = −4.957, $P$ = 0.031), and positively related to participants who lived in urban areas (β = 159.201, $P$ = 0.006).

Multiple regression modelling in Table 7 shows that the FCQ score significantly predicated participant age (β = 0.014, $P$ = 0.045), BMI (β = 0.026, $P < 0.001$), and severity of ID (β = −0.375, $P < 0.001$).

## Discussion

In this exploratory cohort study, young adults with ID were engaging in less physical activity than their age-matched peers and had less nutrient dense diets. The nature and scale of low physical activity levels and poor nutrition in this population have been investigated by multiple studies (Temple and Walkley 2003; McGuire *et al.* 2007; de Winter *et al.* 2012; Hilgenkamp *et al.* 2012; Koritsas and Iacono 2016). This study, however, exclusively examined these factors alongside their cardiometabolic profile to investigate whether associations exist; an important consideration given that knowledge about nutrition and physical activity appears to be an important predictor of cardiometabolic risk.

As with similar studies, the population in our study had a lower prevalence of both smoking and alcohol consumption compared with those without ID, yet it was slightly higher than other studies with similarly aged subjects with disability (McGuire *et al.* 2007; Department of Health and Human Services 2015). Despite this, in our sample, tobacco use and alcohol abuse is unlikely to be a determinant of cardiometabolic risk in young adults with ID.

Prevalence of obesity and overweight, as indicated from measures of waist circumference and BMI was higher in our sample of young people with ID, with the average BMI in the obese category (>30 kg/m$^2$). Prevalence of obesity (61%) was higher compared with other similar studies (Koritsas and Iacono 2016; Oviedo *et al.* 2017; Gawlik *et al.* 2018) and much higher than an older population with ID who presented with 26% obesity (de Winter *et al.* 2012). Previous studies including healthy young adults with excess adiposity revealed that even a small amount of excess weight was associated with worse metabolic, vascular and renal function (Lambert *et al.* 2010a; Lambert *et al.* 2013), hence, this is of concern for adults with ID, even from early adulthood.

There was a noticeable difference in diet quality between those with and without ID in our study. People with ID, in particular those with a mild impairment and those who lived more independently, self-reported poorer nutrition. This is an important finding to further investigate; is this due to ease of food preparation, access to quality food locally, or accessibility of healthy food knowledge for example? It could be hypothesised that people with a milder intellectual impairment are more likely to be able to complete the grocery shopping and prepare and eat a meal independently (unless they have physical limitations); thus, food habits may be self-guided, and thus lend themselves to more education.

Interestingly, there were no differences seen in diet quality between people with ID who attended a day programme versus those who were employed, even though the day programmes included in this study incorporated structured subjects to educate their attendees about food handling, nutrition theory and reading recipes; thus, it was expected to see healthier diets in this subgroup. However, this expected difference was not found, and again, important to investigate further. The need to understand how health promotion information translates into home life has not been investigated thoroughly; and whether the health programmes delivered in day programmes are able to be translated to family groups. Further, it was revealed that carers who supported adults with ID themselves often have significant gaps in the training needs relevant to promoting healthy lifestyle behaviours (Melville *et al.* 2009); hence, they could be an important training target for reinforcing this knowledge across environments.

The current minimum weekly aerobic physical activity guidelines are that Australian adults need to accumulate 150 to 300 min of moderate-intensity physical activity or 75 to 150 min of vigorous-intensity physical activity, or an equivalent combination of both moderate and vigorous activities, each week (Australian Government Department of Health 2014b). This aligns with guidelines in other westernised countries (World Health Organization 2020). Our study has identified that on average, our cohort of young adults with ID are only reaching half the recommended moderate activity minutes or a third of the recommended vigorous activity minutes per week, with the majority accumulated through low intensity activity. Further, people who had a moderate intellectual impairment were associated with lower levels of physical activity. Despite this, no clear link between physical activity and social support was seen, suggesting that people who live more independently have similar levels of physical activity as those who have more living support independent of the severity of their ID. This also needs further exploration; on the one hand,

individuals who have social contacts who support their participation could, for example, have more access to physical activity, but this is dependent on the health knowledge of those supporting them.

In terms of cardiometabolic parameters, some, such as fasting glucose and lipid profile, were comparable with those without ID; however, resting HR was elevated, which is known to be an important predictor for development of hypertension (Julius 1988; Inoue *et al.* 2007). Elevated HR, in combination with high RPP, is significantly associated with total and cardiovascular mortality (Inoue *et al.* 2012), is a worrying observation in this young population. Along with BP, HR and RPP may be important clinical measures for assessing cardiometabolic risk in young adults with intellectual disabilities (Lambert *et al.* 2010b; Lambert *et al.* 2017). Additionally, it has been suggested that high HR is a predictor for cardiac events and metabolic syndrome (Inoue *et al.* 2009) and is a proven, and accessible biomarker of cardiac sympathetic activation (Esler *et al.* 2020). Sympathetic hyperactivity has been associated with excess abdominal adiposity (Alvarez *et al.* 2002; Lambert *et al.* 2010a), which was prevalent in this cohort. Impaired autonomic function (Zwack *et al.* 2021) and elevated plasma Hba1c, along with clear evidence of overweight/obesity, indicate that this group of young adults with ID are at increased risk of CVD compared with their peers. Preliminary results indicate that the combination of reported diet high in discretionary foods (high salt, high fat, low in essential nutrients) and reduced physical activity are likely to have contributed to the elevated Hba1c and abdominal obesity seen in this group. In other populations, it has been demonstrated that a moderate and structured increase in physical activity will affect reducing Hba1c levels (Umpierre *et al.* 2011; Boniol *et al.* 2017). Thus, there is good evidence to further research the effect of appropriate exercise interventions in young adults with ID.

When looking at food knowledge in this study, understanding nutrition terminology and energy requirements were challenging concepts for the group with ID, and low scores in these subscales were found to be associated with increased body weight and BMI. There were also associations found between reduced health knowledge and increased insulin levels and elevated blood pressure in people with ID, hence, it may be an important predictor of cardiometabolic risk in this population. On the other hand, young adults with ID demonstrated similar ability as those without ID in identifying what food or which physical activity was the healthiest (or best) choice when provided with several options. In line with other studies (Caton *et al.* 2012), our cohort were able to point out a healthy meal or activity, but further exploration is needed as to how this translates into the application in day to day life; specifically what the barriers are to implementation. Unsurprisingly, people with a moderate intellectual impairment were identified as having more difficulties comprehending health-related knowledge than those with milder impairments, highlighting the need for group-specific support for making participative health-related decisions (i.e. targeting people with mild ID separate to those with a moderate ID).

We identified cardiometabolic risk factors, such as reduced physical activity and unhealthy diets, in a population of young adults with ID when compared with their peers. It is essential to further investigate the reasons for this, particularly as the group were able to identify what was a healthy activity or diet, but seemingly not completing this. In regional communities in particular, the impact of food deserts (Kelli *et al.* 2019) and socioeconomic status restricting meal budgeting and opportunities for physical activity may also be important contributing factors.

The cross-sectional aspect of our study does not permit the determination of causality; however, what is quite clear is that there are identifiable links between modifiable risk factors and cardiometabolic risk profile in young adults with ID. Thus, further investigation into actively supporting people with ID to modify health related behaviours is urgently needed. Even though health education programmes addressing diet and physical activity are delivered in this population (Abdullah and Horner-Johnson 2006; Marks *et al.* 2010), particularly to those who attend centre-based disability programmes, this does not appear to be translated into practice for our group. There is a pressing need to explore what support is required and to evolve more rapidly to develop tailored and long-term health literacy for all young adults with ID, by not only disability service staff and researchers, but also practitioners, caregivers and family. More experimental interventions and

longitudinal research are required to study the ways that people with ID learn and use nutrition and activity-related knowledge to achieve their personal health goals.

There are limitations to this study that affect its generalisability. The group of people with ID were a sample of convenience (recruited primarily through a disability organisation which supported the project); however, the sample included a diverse range of demographics (geographical location, severity of impairment, aetiology of ID for example) and was ideal for an exploratory study. We also acknowledge that the study group is relatively small in size; however, performing the physical assessments with individuals with ID was demanding and required special consideration. Additional time was also required to obtain informed consent. Hence, the number of subjects recruited for participation was limited to ensure the study was completed in the allocated timeframe.

Inclusion of participants in the ID group with reported CVD had the potential to confound the results; however, significance remained after exclusion of these subjects from data analysis. We also considered subgrouping by aetiology of ID; however, the group sizes were too small to include in the analysis. Use of psychotropic medications has been linked to metabolic side effects such as dyslipidaemia and glucose dysregulation in the general population (Casey 2005), and obesity (de Winter *et al.* 2012) and metabolic syndrome (Room *et al.* 2016) in people with ID. Whilst we did not see any clear differences in the cardiometabolic profile of people with ID who were and were not taking psychotropic medications, a larger sample is required to conclude whether this class of medication may exacerbate the already elevated risk for cardiometabolic diseases in this young population.

This study is part of a larger exploratory project examining mechanisms of CVD risk in people with ID, and a large battery of physical assessments and questionnaires were administered in a three-hour assessment window. Self-report 7-day recall was selected as the simplest and quickest method for obtaining information about physical activity levels. Self-report measures have been shown to lead to both higher and lower activity levels when compared with objectively measured levels of physical activity, with no clarity about whether more people overestimate or underestimate their activity (Prince *et al.* 2008). To improve the reliability of this evidence, in future cohort studies, we will aim to directly measure activity levels using measurement devices such as a wearable activity trackers and HR monitors.

Utilising the long version of NAKS is also recommended for future studies to provide a more comprehensive overview of health knowledge. Moreover, because of the success in this study population, we aim to formally validate the FCQ and shortened version of the NAKS in the near future. Lastly, several subjects attended the session with caregivers, and when unable to answer a question, the caregiver was asked to provide an answer on their behalf. Second-hand reporting of health behaviours may have influenced the results, especially as it was not noted how long the caregiver had known the subject.

## Conclusions

This study provides a preliminary overview of the prevalence of modifiable risk factors and the cardiometabolic health profile of young adults with ID, and comparison with a healthy population of the same age. The issues identified in this study include obesity and the factors relating to the condition, including low levels of physical activity and unhealthy diet. Other concerns are metabolic risk factors including impaired glycaemic control and elevated heart rate, highlighting that these may be important clinical measures for assessing cardiometabolic risk in young adults with intellectual disabilities.

Further exploration into the development and implementation of a health promotion programme specific for young people with ID will be of great benefit to their cardiometabolic health outcomes. However, whilst health promotion can provide a foundational health knowledge, it will likely need to be considered in combination with other interventions addressing social and environmental factors related to health.

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## Conflict of interest

The authors declare no conflict of interest.

## Data availability statement

The data that support the findings of this study are available upon reasonable request from the corresponding author, C. Z.

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## Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article.

**Data S1.** Supporting information