JIDR Journal of Intellectual Disability Research
Published on behalf of mencap and in association with IASSID

VOLUME PART 2023

Associations between physical fitness and cardiovascular disease in older adults with intellectual disabilities: Results of the Healthy Ageing and Intellectual Disability study

M. J. de Leeuw,[1] **A. Oppewal,**[1] **R. G. Elbers,**[1] **T. I. M. Hilgenkamp,**[1,2] **P. J. E. Bindels**[1] **& D. A. M. Maes-Festen**[1]

1 *Department of General Practice, Intellectual Disability Medicine - Erasmus MC, University Medical Center, Rotterdam, The Netherlands*
2 *Department of Physical Therapy, University of Nevada, Las Vegas, NV, USA*

Abstract

Background Reduced physical fitness is a cardiovascular disease (CVD) risk factor in the general population. However, generalising these results to older adults with intellectual disabilities (ID) may be inappropriate given their pre-existing low physical fitness levels and high prevalence of co-morbidities. Therefore, the aim of this study is to investigate the difference in physical fitness between older adults with ID with and without CVD.
Method Baseline data of a cohort of older adults with borderline to profound ID (HA-ID study) were used (n = 684; 61.6 ± 8.2 years; 51.3% male). CVD status (coronary artery disease, heart failure, stroke) was obtained from medical files. Cardiorespiratory fitness (10-m incremental shuttle walking test), comfortable and fast gait speed (over 5 m distance) and grip strength (hand dynamometer) were measured. Multivariable linear regression models were used to investigate the association between these physical fitness components and the presence of CVD, adjusted for participant characteristics.
Results Of the 684 participants 78 (11.4%) had CVD. Participants with CVD scored lower on cardiorespiratory fitness (−81.4 m, P = 0.002), comfortable gait speed (−0.3 km/h, P = 0.04) and fast gait speed (−1.1 km/h, P = 0.04). No significant differences were found for grip strength (−0.2 kg, P = 0.89).
Conclusions Older adults with CVD had significantly lower physical fitness levels than those without CVD, except for grip strength. Longitudinal research is needed to investigate causality.

Keywords Cardiorespiratory fitness, Cardiovascular disease, Gait speed, Grip strength, Intellectual disability, Physical fitness

Correspondence: Marleen J. de Leeuw, Department of General Practice, Intellectual Disability Medicine, Erasmus MC, University Medical Center, P.O. Box 2040, 3000 CA Rotterdam, The Netherlands (e-mail: m.j.deleeuw@erasmusmc.nl).

Background

Cardiovascular diseases (CVD), including coronary artery disease, heart failure and stroke, account for almost one-third of all deaths worldwide (World Health Organization 2021). These diseases are not only an important health issue for the population at large; they are also associated with high morbidity and mortality in people with intellectual disabilities (ID) (Patja *et al.* 2001; Van Den Akker *et al.* 2006). Several studies, mainly based on retrospective medical file research, suggest that the prevalence and incidence of CVD in older people with ID are equal to that in the general population (Jansen *et al.* 2013; De Winter *et al.* 2016).

Risk factors for CVD include hypertension, hypercholesterolaemia, diabetes, smoking, obesity and family history of premature CVD (Visseren *et al.* 2021). Compared with the general population, hypertension (Flygare Wallén *et al.* 2018), diabetes (Flygare Wallén *et al.* 2018) and obesity (De Winter *et al.* 2012b; Flygare Wallén *et al.* 2018) are more often present in people with ID. CVD risk factors are especially common in people with a mild level of ID, who live more independently and make their own lifestyle decisions (De Winter *et al.* 2012a). Furthermore, some people with ID have increased CVD risk due to syndrome-specific risk factors, such as people with Prader–Willi syndrome (Sinnema *et al.* 2011; Nordstrøm *et al.* 2016) and cerebral palsy (Strauss *et al.* 1999).

Research in the general population showed that physical fitness (U.S. Department of Health and Human Services 2008; American College of Sports Medicine 2021), especially cardiorespiratory fitness (Myers *et al.* 2015; Ozemek *et al.* 2018; Kaminsky *et al.* 2019), is an important factor in the risk of CVD. Also, slow gait speed (Fonseca Alves *et al.* 2017; Veronese *et al.* 2018) and low grip strength (Wu *et al.* 2017; Tikkanen *et al.* 2018) are predictive for a higher risk of CVD and cardiovascular mortality. These results may not be generalisable to people with ID in whom very low physical fitness levels have been found (Salaun and Berthouze-Aranda 2012; Hilgenkamp *et al.* 2012b; Oppewal *et al.* 2013). The physical fitness levels of older adults with ID, aged 50 years and over, were comparable to, or even worse than, those of adults in the general population who were 20 years older (Hilgenkamp *et al.* 2012b). Given these overall low physical fitness levels, combined with the high prevalence of co-morbidities at a younger age (Reppermund and Trollor 2016), physical fitness might be less discriminative between people with ID with and without CVD.

Therefore, this study investigated the difference in physical fitness levels between older adults with ID with and without CVD. We hypothesised that adults with CVD had significantly lower physical fitness levels than those without CVD for the physical fitness components cardiorespiratory fitness, gait speed and grip strength.

Methods

Study design and participants

Baseline data from the Healthy Ageing and Intellectual Disability (HA-ID) study were used. The HA-ID study is a prospective multicentre cohort study on the physical and mental health of older adults with ID who use formal ID support. A detailed description of the design and recruitment of the HA-ID study has been published elsewhere (Hilgenkamp *et al.* 2011). Currently, the 10-year follow-up of the HA-ID study is being performed (De Leeuw *et al.* 2022). However, in the present study, we will focus on the baseline data only. The data collection of the HA-ID study was conducted in three participating ID care organisations (Abrona, Amarant and Ipse de Bruggen) that provide support to a wide spectrum of individuals with ID in different care settings in the Netherlands. All individuals with ID who received care or support from one of these three care organisations, and who were 50 years or older on 1 September 2008, were eligible to participate and received an invitation. All data were collected between February 2009 and July 2010.

Two separate consent procedures were followed. A behavioural scientist evaluated whether potential participants were able to understand the study information and to make an informed decision about participation. If yes, they were sent an easy-to-read information letter with supporting pictures and consent form and signed the consent form themselves. For individuals who were unable to give informed consent, informed consent was requested from their legal representative. Efforts were made to inform the individuals who could not provide consent themselves. At all times, resistance by the participant to parts of the measurements was leading in deciding to perform the measurements. To assure safe participation to the physical fitness test, the Revised Physical Activity Readiness Questionnaire (PAR-Q) was administered by professional caregivers prior to the data collection (Thomas *et al.* 1992). If any of the questions were answered with 'yes' or 'unknown', the physician of the participant was consulted to determine whether the participant could safely take part in the physical fitness measurements.

Ethical approval was obtained from the Medical Ethics Review Committee of the Erasmus MC, University Medical Center Rotterdam (MEC-2008-234). This study follows the guidelines of the Declaration of Helsinki (World Medical Association, 2013).

Measurements

Participant characteristics

Data on age and sex were collected from the administrative electronic systems of the care organisations. Data about residential status (central setting, community based, independent with ambulatory support, with relatives) were collected through a questionnaire completed by the participant's professional caregiver. Information about the level of ID was collected from psychologists' and behavioural therapists' files and categorised as borderline [intelligence quotient (IQ) 70–80], mild (IQ = 55–70), moderate (IQ = 35–55), severe (IQ = 25–35) or profound (IQ < 25) based on the International Classification of Diseases (ICD-10) criteria (World Health Organization 1996). Information on the presence of Down syndrome (yes, no, unknown) was retrieved from the participant's medical file.

Cardiovascular disease and cardiovascular disease risk factors

The participant's personal physician was asked to provide information about whether the participant had ever been diagnosed with coronary artery disease, heart failure or stroke. The diagnoses were based on events or episodes in the participant's medical file. Participants with at least one of these three CVD diagnoses in their medical file were classified as having 'CVD'. Participants without one of these diagnoses in their medical file were classified as having 'no CVD'.

The following CVD risk factors were measured [exact procedures are described elsewhere (De Winter *et al.* 2012a; De Winter *et al.* 2012b; De Winter *et al.* 2014)]: hypertension (mean systolic blood pressure ≥140 mmHg or a mean diastolic blood pressure ≥90 mmHg or the use of blood pressure lowering drugs) (De Winter *et al.* 2012a), hypercholesterolaemia (fasting serum total cholesterol >6.5 mmol/L or the use of lipid-lowering drugs) (De Winter *et al.* 2012a), diabetes mellitus (fasting serum glucose >6.1 mmol/L or the use of glucose-lowering drugs) (De Winter *et al.* 2012a), body mass index (BMI) (De Winter *et al.* 2012b), waist circumference (De Winter *et al.* 2012b), waist to hip ratio (De Winter *et al.* 2012b), metabolic syndrome (according to the criteria of the joint interim statement 2009) (Alberti *et al.* 2009; De Winter *et al.* 2011), inflammation (elevated C-reactive protein >10 mg/L) (De Winter *et al.* 2014) and chronic kidney disease (glomerular filtration rate according to the CKD–creatinine–cystatin-C equation <60 ml/min/1.73 m^2) (Inker *et al.* 2012; De Winter *et al.* 2014). Data about smoking at least one cigarette/day (yes, no) were collected through a questionnaire completed by the participant's professional caregiver. Information on the use of antipsychotics was retrieved from the participant's medical file.

Physical fitness

Cardiorespiratory fitness was measured with the 10-m incremental shuttle walking test (Singh *et al.* 1992). Participants walked back and forth on a 10-m course at increasing speed. They started at 0.50 m/s, and the walking speed increased every minute by 0.17 m/s. The test ended when the participant failed to complete a 10-m shuttle within the allowed time. The test was performed twice, and the test with the best effort (during which the participant attained the highest peak heart rate) was regarded as the best test and used in the analyses. The test score was the distance (m) covered by the participant during the test.

Gait speed was evaluated by measuring the time it took to cover 5 m, after 3 m for acceleration, with an additional 3 m at the end for deceleration. Participants walked at comfortable gait speed and at fast gait speed (Bohannon 1997). Participants walked three times for each condition. For comfortable gait speed, the three trials were averaged. For fast gait speed, the fastest trial was the result. Gait speed was measured in m/s and converted into km/h.

Grip strength was measured with the Jamar Hand Dynamometer (#5030J1, Sammons Preston Rolyan, USA) (Fess and Moran 1981). Participants squeezed the dynamometer with maximum force in a seated position according to the recommendations of the American Society of Hand Therapists (Fess and Moran 1981). Three attempts were performed for both hands with 1-min rest in between. The test result was the maximal produced force in either one of the hands (in kg).

A more detailed description of the tests and the execution can be found elsewhere (Oppewal *et al.* 2014). The feasibility and reliability of these instruments are good in older adults with ID (Hilgenkamp *et al.* 2012a; Hilgenkamp *et al.* 2013), and validity and reliability have also been confirmed in the general population (Singh *et al.* 1992; Singh *et al.* 1994; Steffen *et al.* 2002; Abellan Van Kan *et al.* 2009; Stark *et al.* 2011; Abizanda *et al.* 2012).

Physiotherapists, occupational therapists and physical activity instructors with experience in working with people with ID conducted the physical fitness tests. Prior to data collection, all test instructors received an instruction manual and training for the execution of the tests. The test instructors were trained in the standardised instruction and execution of all the tests, and if a participant was not able to understand the test instructions or not able to execute the test according to the test description, the test was deemed invalid. All assessors were blinded for the participant's CVD status. Participants had the opportunity to practice each test to make sure they understood the test.

Statistical analysis

Only participants with available medical file information about their CVD status who participated in the physical fitness tests were included in the statistical analysis. Descriptive statistics were used to describe the participant characteristics, presence of CVD risk factors and CVD and the physical fitness levels. Differences in characteristics and physical fitness levels between participants with CVD and participants without CVD were analysed with independent *t*-tests for continuous variables and chi-square tests for categorical variables.

After assumptions were checked, multivariable linear regression models were used to investigate the association between the physical fitness components (dependent variables) and the presence of CVD (independent variable), adjusted for participant characteristics (age, sex, residential status, level of ID and Down syndrome). For each of the four physical fitness components, one multivariable linear regression model was built. All independent variables were entered into the multivariable regression model simultaneously. Multicollinearity was checked with the variance inflation factor (which had to be below 10) and tolerance values (which had to be higher than 0.1) (Field 2013). Statistical significance was set at $P < 0.05$. Analyses were performed using IBM SPSS statistics version 25.0 (IBM Corporation, New York).

Results

Participant characteristics

Of the 2322 invited individuals, 1050 (45.2%) consented to participate and were included in the HA-ID cohort. Of the total cohort, 684 participants (65.1%) had complete data and were included in the analysis. Reasons for exclusion were the unavailability of medical file information ($n = 151$, 14.4%) and non-participation in the physical fitness tests ($n = 233$, 22.2%). Reasons for no participation in the physical fitness tests were not being able to walk and a lack of understanding of instructions or test execution, primarily by participants with a profound or severe level of ID.

Table 1 summarises the characteristics of the participants with and without a diagnosis of CVD in their medical file. The mean age of the study sample was 61.6 years (standard deviation = 8.2), and 51.3% of the participants were male. Most of the participants lived in a central setting (54.2%) or in the community (41.1%) and had a mild (22.1%), moderate (52.8%) or severe (15.9%) level of ID. Down syndrome was diagnosed in 14.9% of the participants. Participants with CVD were significantly older than participants without CVD (mean difference 8.3 years; $P < 0.001$) and had less often Down syndrome (3.8% vs. 16.3% respectively; $P = 0.01$).

Cardiovascular disease and cardiovascular disease risk factors

Seventy-eight participants (11.4%) had at least one diagnosis of CVD in their medical file at the time of the physical fitness tests. In the medical files of these participants, a total of 18 diagnoses of coronary artery

Table 1 Baseline characteristics of the study sample

		CVD in medical file n = 78 (11.4%)	No CVD in medical file n = 606 (88.6%)	P-value
Participant characteristics				
Age	Mean (SD)	69.1 (9.9)	60.8 (7.4)	<**0.001**
	50–59 years n (%)	12 (15.4%)	307 (50.7%)	
	60–69 years n (%)	30 (38.5%)	204 (33.7%)	
	70–79 years n (%)	27 (34.6%)	88 (14.5%)	
	80 + years n (%)	9 (11.5%)	7 (1.2%)	
Sex n (%)	Male	39 (50%)	312 (51.5%)	0.81
	Female	39 (50%)	294 (48.5%)	
Residential status n (%)	Central setting	42 (53.8%)	329 (54.3%)	0.90
	Community based	33 (42.3%)	248 (40.9%)	
	Independent with ambulatory support	2 (2.6%)	21 (3.5%)	
	With relatives	1 (1.3%)	4 (0.7%)	
	Unknown	0 (0%)	4 (0.7%)	
Level of ID n (%)	Borderline	3 (3.8%)	17 (2.8%)	0.87
	Mild	17 (21.8%)	134 (22.1%)	
	Moderate	43 (55.1%)	318 (52.5%)	
	Severe	11 (14.1%)	98 (16.2%)	
	Profound	2 (2.6%)	30 (5%)	
	Unknown	2 (2.6%)	9 (1.5%)	
Down syndrome n (%)	No	71 (91%)	484 (79.9%)	**0.01**
	Yes	3 (3.8%)	99 (16.3%)	
	Unknown	4 (5.1%)	23 (3.8%)	
CVD risk factors				
Hypertension n (%)	No	25 (32.1%)	307 (50.7%)	**0.002**
	Yes	53 (67.9%)	298 (49.2%)	
	Unknown	0 (0%)	1 (0.2%)	
Hypercholesterolaemia n (%)	No	28 (35.9%)	351 (57.9%)	<**0.001**
	Yes	29 (37.2%)	102 (16.8%)	
	Unknown	21 (26.9%)	153 (25.2%)	
Diabetes mellitus n (%)	No	47 (60.3%)	396 (65.3%)	0.30
	Yes	10 (12.8%)	57 (9.4%)	
	Unknown	21 (26.9%)	153 (25.2%)	
BMI in kg/m^2	Mean (SD)	28.7 (5.0)	27.3 (5.2)	**0.03**
Waist circumference in cm	Mean (SD)	98.8 (11.4)	94.2 (13.4)	**0.005**
Waist to hip ratio	Mean (SD)	0.9 (0.1)	0.9 (0.1)	0.47
Smoking n (%)	No	49 (62.8%)	460 (75.9%)	**0.01**
	Yes	29 (37.2%)	146 (24.1%)	
	Unknown	0 (0%)	0 (0%)	
Use of antipsychotics n (%)	No	60 (76.9%)	446 (73.6%)	0.50
	Yes	17 (21.8%)	154 (25.4%)	
	Unknown	1 (1.3%)	6 (1%)	
Chronic kidney disease n (%)	No	33 (42.3%)	341 (56.3%)	<**0.001**
	Yes	17 (21.8%)	52 (8.6%)	
	Unknown	28 (35.9%)	213 (35.1%)	
Metabolic syndrome n (%)	No	14 (17.9%)	219 (36.1%)	**0.001**
	Yes	34 (43.6%)	184 (30.4%)	
	Unknown	30 (38.5%)	203 (33.5%)	

Table 1. *(Continued)*

		CVD in medical file n = 78 (11.4%)	No CVD in medical file n = 606 (88.6%)	P-value
C-reactive protein (>10 mg/L) n (%)	No	48 (61.5%)	397 (65.5%)	0.68
	Yes	8 (10.3%)	56 (9.2%)	
	Unknown	22 (28.2%)	153 (25.2%)	

P-value = $P < 0.05$ is statistically significant.

BMI, body mass index; cm, centimetre; CVD, cardiovascular disease (coronary artery disease, heart failure or stroke); ID, intellectual disability; kg/m^2, kilogram per square metre; n, number of participants; SD, standard deviation.

disease (2.6%), 26 diagnoses of heart failure (3.8%) and 42 diagnoses of stroke (6.1%) were found. Four participants were diagnosed with heart failure and coronary artery disease, three participants with heart failure and stroke and one participant with coronary artery disease and stroke.

Table 1 shows the presence of CVD risk factors of participants with and without CVD. Compared with participants without CVD, participants with CVD smoked significantly more often (37.2% vs. 24.1%, respectively; P = 0.01), had a significantly higher BMI (28.7 vs. 27.3 kg/m^2, respectively; P = 0.03) and waist circumference (98.8 vs. 94.2 cm, respectively; P = 0.005) and significantly more often had hypertension (67.9% vs. 49.2%, respectively; P = 0.002), hypercholesterolaemia (37.2% vs. 16.8%, respectively; P < 0.001), chronic kidney disease (21.8% vs. 8.6%, respectively; P < 0.001) and metabolic syndrome (43.6% vs. 30.4%, respectively; P = 0.001).

Physical fitness and cardiovascular disease

The unadjusted physical fitness scores of the participants with and without CVD are presented in Table 2. Participants with CVD had significantly lower scores on cardiorespiratory fitness (136.9 m vs. 244.1 m, respectively; P = <0.001), comfortable gait speed (2.8 km/h vs. 3.5 km/h, respectively; P = <0.001) and fast gait speed (4.7 km/h vs. 6.5 km/h, respectively; P = 0.002) compared with participants without CVD. No significant difference was found between the two groups for the physical fitness component grip strength (22.7 kg vs. 24.0 kg, respectively; P = 0.29).

Table 3 presents the results of the multivariable linear regression models we performed to investigate the difference in physical fitness levels between older adults with ID with and without CVD. This table shows the regression coefficients and associated 95% confidence interval and P-value for the presence of

Table 2 Physical fitness results of the CVD and no CVD group

Physical fitness	CVD in medical file Mean (SD) n = 78 (11.4%)	No CVD in medical file Mean (SD) n = 606 (88.6%)	B (95% CI)	P-value
Cardiorespiratory fitness in m†	136.9 (93.3)	244.1 (170.5)	−107.2 (−164.5 to −49.9)	**<0.001**
Comfortable gait speed in km/h†	2.8 (1.2)	3.5 (1.2)	−0.7 (−1.0 to −0.3)	**<0.001**
Fast gait speed in km/h†	4.7 (2.3)	6.5 (3.1)	−1.8 (−3.0 to −0.7)	**0.002**
Grip strength in kg†	22.7 (10.1)	24.0 (10.0)	−1.3 (−3.8 to 1.1)	0.29

P-value = $P < 0.05$ is statistically significant.

B, beta; CI, confidence interval; CVD, cardiovascular disease (coronary artery disease, heart failure or stroke); kg, kilogram; km/h, kilometres per hour; m, metre; n, number of participants; SD, standard deviation.

†A higher score represents a better performance.

Table 3 Cross-sectional associations between four physical fitness components and CVD, adjusted for participant characteristics (multivariable linear regression analyses)

		Cardiorespiratory fitness (walked distance m)†			Comfortable gait speed (km/h)†			Fast gait speed (km/h)†			Grip strength (kg)†		
		B	95% CI	*P*-value	B	95% CI	*P*-value	B	95% CI	*P*-value	B	95% CI	*P*-value
Constant		661.2	537.6 to 784.8	<**0.001**	6.7	5.9 to 7.5	<**0.001**	15.8	13.4 to 18.1	<**0.001**	42.1	36.4 to 47.9	<**0.001**
CVD	No	0 (ref)			0 (ref)			0 (ref)			0 (ref)		
	Yes	−81.4	−134.1 to −28.8	**0.002**	−0.3	−0.7 to −0.02	**0.04**	−1.1	−2.2 to −0.1	**0.04**	−0.2	−2.3 to 1.9	0.89
Age	In years	−6.1	−8.0 to −4.2	<**0.001**	−0.04	−0.1 to −0.04	<**0.001**	−0.1	−0.2 to −0.1	<**0.001**	−0.2	−0.3 to −0.1	<**0.001**
Sex	Male	0 (ref)			0 (ref)			0 (ref)			0 (ref)		
	Female	−63.1	−89.7 to −36.5	<**0.001**	−0.5	−0.6 to −0.3	<**0.001**	−1.8	−2.4 to −1.4	<**0.001**	−9.2	−10.5 to −7.8	<**0.001**
Residential status	Central setting	0 (ref)			0 (ref)			0 (ref)			0 (ref)		
	Community based	80.2	50.6 to 109.8	<**0.001**	0.5	0.3 to 0.7	<**0.001**	1.1	0.6 to 1.6	<**0.001**	2.8	1.4 to 4.2	<**0.001**
	Independent with ambulatory support	85.0	10.8 to 159.2	**0.03**	0.8	0.3 to 1.3	**0.001**	1.2	−0.1 to 2.6	0.08	3.1	−0.5 to 6.7	0.09
	With relatives	−54.5	−200.9 to 91.8	0.47	−0.2	−1.1 to 0.8	0.73	1.7	−1.3 to 4.7	0.27	1.6	−6.5 to 9.6	0.70
Level of ID	Borderline to mild	0 (ref)			0 (ref)			0 (ref)			0 (ref)		
	Moderate	−55.5	−88.2 to −22.8	<**0.001**	−0.3	−0.5 to −0.04	**0.02**	−0.5	−1.1 to 0.1	0.09	−3.8	−5.4 to −2.2	<**0.001**
	Severe to profound	−79.1	−122.5 to −35.7	<**0.001**	−0.7	−1.0 to −0.4	<**0.001**	−1.7	−2.6 to −0.9	<**0.001**	−8.5	−10.9 to −6.1	<**0.001**
Down syndrome	No	0 (ref)			0 (ref)			0 (ref)			0 (ref)		
	Yes	−70.5	−109.4 to −31.6	<**0.001**	−0.4	−0.7 to −0.2	**0.002**	−0.4	−1.1 to 0.4	0.32	−4.7	−6.7 to −2.7	<**0.001**

P-value = $P < 0.05$ is statistically significant.

B, beta; CI, confidence interval; CVD, cardiovascular disease (coronary artery disease, heart failure or stroke); ID, intellectual disability; kg, kilogram; km/h, kilometres per hour; m, metre.

†A higher score represents a better performance.

CVD in relation to each of the four physical fitness components. After adjusting for age, sex, residential status, level of ID and Down syndrome, participants with CVD scored significantly lower on cardiorespiratory fitness, comfortable gait speed and fast gait speed. Participants with CVD walked an average of 81.4 m less on the cardiorespiratory fitness test ($P = 0.002$), walked on average 0.3 km/h slower during the comfortable gait speed test ($P = 0.04$) and walked on average 1.1 km/h slower during the fast gait speed test ($P = 0.04$) compared with participants without CVD. In accordance with the unadjusted results, no significant differences between both groups were found for physical fitness component grip strength ($P = 0.89$). All participant characteristics showed a significant relationship with physical fitness in most of the models. In general, participants who were younger, who were male, who had borderline or mild ID, who did not have Down syndrome and who lived more independently had better physical fitness levels.

Discussion

In this study, we investigated the difference in physical fitness levels between older adults with ID with and without CVD. Participants with CVD had significantly lower physical fitness levels than those without CVD for the physical fitness components cardiorespiratory fitness, comfortable gait speed and fast gait speed. We found no statistically significant difference between the two groups for grip strength.

Our study specifically looked at the physical fitness levels of participants who have CVD compared to those who have no CVD. Despite the already very low physical fitness levels of older adults with ID (Hilgenkamp *et al.* 2012b), the physical fitness scores of participants with CVD were even worse. Participants with CVD scored significantly lower on most physical fitness tests: They walked fewer metres on the cardiorespiratory fitness test and had a lower comfortable and fast gait speed compared with participants without CVD. Hilgenkamp *et al.* (2012b) previously reported very low physical fitness levels in the HA-ID cohort. The participants (aged 50 years and over) performed comparable or even worse than people in the general population who were 20 years older (Hilgenkamp *et al.* 2012b). This implicates that physical fitness might be a target for improvement of cardiovascular health in older adults with ID and those with CVD in particular. Oppewal *et al.* (2020) hypothesised that even among very unfit people with ID, small improvements in physical fitness may lead to major improvements in health (Oppewal *et al.* 2020). This may also be the case for cardiovascular health. Therefore, health promotion focussing on improving physical fitness and reducing CVD risk is important. However, existing health promotion and prevention programmes to reduce CVD risk are often not fully suited for older adults with ID and should be adjusted for this population.

From research in the general population, it is known that several physical fitness components are predictive for CVD morbidity and mortality, with the strongest evidence for cardiorespiratory fitness (Myers *et al.* 2015; Ozemek *et al.* 2018; Kaminsky *et al.* 2019), gait speed (Fonseca Alves *et al.* 2017; Veronese *et al.* 2018) and grip strength (Wu *et al.* 2017; Tikkanen *et al.* 2018). Our results are in line with those seen in the general population, showing that the presence of CVD is associated with cardiorespiratory fitness and gait speed in older adults with ID. In general, participants who were younger, who were male, who had borderline or mild ID, who did not have Down syndrome and who lived more independently had better physical fitness levels. We did not find a relationship between the presence of CVD and grip strength. This is in line with results of previous studies of the HA-ID cohort in which we also found no relationship between grip strength and other outcome measures known from research in the general population, such as (instrumental) activities or daily living (Oppewal *et al.* 2014; Oppewal *et al.* 2015).

In this study, we found a prevalence of coronary artery disease of 2.6%, a prevalence of heart failure of 3.8% and a prevalence of stroke of 6.1% in older adults with ID. The overall prevalence of CVD (coronary artery disease, heart failure or stroke) found in our cohort was 11.4%. These prevalence rates are largely in line with results of previous studies in (older) adults with ID (Jansen *et al.* 2013; Cooper *et al.* 2018), although wide variations in CVD prevalence rates are reported (Dunkley *et al.* 2017; Van Den Bemd *et al.* 2022). Overall, the prevalence of CVD we found in older adults with ID seems to fall in the range of the prevalence in the general Dutch population (Nederlandse Hart Registratie and

Hartstichting 2022), which is in agreement with findings from previous studies (Jansen *et al.* 2013; De Winter *et al.* 2016). However, at the same time, the literature describes a higher prevalence of several CVD risk factors in adults with ID (De Winter *et al.* 2012b; Flygare Wallén *et al.* 2018). This discrepancy in prevalence rates suggests that CVD may be underdiagnosed in this group. This is also supported by previous research on peripheral arterial disease (PAD), which showed a higher prevalence of PAD in older adults with ID compared with the general population (17.4% vs. 8.1%, respectively) and a high degree of underdiagnosis in older adults with ID (97% of the participants with PAD had not been previously diagnosed with this condition) (De Winter *et al.* 2013). This may be explained by the fact that diagnostics in people with ID are more challenging because of atypical presentation of symptoms, limitations in articulating health problems and limited cooperation and resilience during physical examination (Lennox *et al.* 1997; Van Eeghen *et al.* 2019). Referral policies for this vulnerable group are made with the greatest possible care and in consultation with physicians, representatives, healthcare staff and others involved, which can sometimes lead to, for example, the choice to refrain from further diagnosis in the interest of the individual's quality of life (Wagemans 2013). As a result, the actual prevalence of CVD in people with ID might be higher than reported in our study and in previous publications (Jansen *et al.* 2013; De Winter *et al.* 2016).

Strengths of this study are the extensive physical fitness tests at baseline and the large sample size. To our knowledge, this is the first study that investigated the cross-sectional associations between the presence of CVD and various physical fitness components in older adults with ID. However, some limitations of this study should be noted. The HA-ID cohort consists of adults who receive any form of registered formal ID care or support. The HA-ID cohort is near-representative for this population (Hilgenkamp *et al.* 2011), but our results are not generalisable for all adults with ID because we did not include adults without formal ID care. In addition, dropout during the physical fitness tests resulted in under-representation of people who were not able to walk, or had severe or profound ID, and an over-representation of adults of 50–59 years, who walked independently and who had borderline or mild ID (Hilgenkamp *et al.* 2012b). When interpreting the findings of this study, it is important to take these points into account. It should also be noted that due to a lack of statistical power we had to use the physical fitness components as dependent variables in the multivariable linear regression models instead of the presence of CVD. For this reason, we were unable to adjust for CVD risk factors in the multivariable analysis. Also, it is important to point out that the CVD status of the participants was only based on medical file research. For this reason, we must acknowledge that we cannot rule out underdiagnosis of CVD in our study. Finally, due to the cross-sectional data collection, it is not possible to make statements about causality based on the results of this study. It is possible that people with lower physical fitness levels are more likely to get CVD, but it could also be that people with CVD are less physically fit because of their condition. For this reason, this study should be seen as a first exploration of the relationship between physical fitness and CVD in older adults with ID.

Based on the findings in this study, our recommendations for future research are the following. First, in addition to the participant characteristics in this study, other (population-specific) factors may influence both physical fitness and cardiovascular health in older adults with ID. Therefore, it would be interesting to include additional factors, such as other genetic syndromes, medication use, specific physical and psychiatric co-morbidities and CVD risk factors, in the analyses of future research. Second, to overcome possible underdiagnosis of CVD in future research, it would be of great value to use more objective measures for diagnosing CVD in people with intellectual disabilities, for example, by using electrocardiogram or cardiac ultrasound measurements. Finally, we assessed the association between physical fitness and CVD at a single time point. Longitudinal follow-up research will provide a deeper understanding of the course of physical fitness and CVD over time and allows to make causality statements about the impact of physical fitness on developing CVD in older adults with ID. This knowledge is needed to get insight into the dose–response relationship between changes in physical fitness and the resulting decrease or increase in risk for developing CVD in older adults with ID.

Some studies show that exercise interventions increase physical fitness and decrease CVD risk factors in people with ID (Boer *et al.* 2014; Boer and Moss 2016; Bouzas *et al.* 2019). However, the available evidence is still limited, which impairs the provision of clear training prescriptions (Oppewal *et al.* 2020). For this reason, we strongly recommend longitudinal and intervention research into this topic. We are currently working on the 10-year follow-up of the HA-ID cohort (De Leeuw *et al.* 2022), which will allow us to explore such longitudinal questions in the future.

In conclusion, this study shows that older adults with ID who have CVD had significantly lower physical fitness levels (cardiorespiratory fitness, comfortable gait speed and fast gait speed) than those without CVD. Grip strength was not significantly associated with the presence of CVD. Longitudinal follow-up research in adults with ID is needed to study the relationship between physical fitness and CVD over time to make statements about the direction of the relationship and causality. It will also help to gain more insight into what extent physical fitness is an important target area for prevention and interventions to improve cardiovascular health of adults with ID.

Acknowledgements

The authors thank the Dutch care organisations, Abrona, Amarant and Ipse de Bruggen, involved in the HA-ID consortium for their collaboration and financial support. We would also like to thank the professionals of these organisations as well as all participants, their family members and caregivers for their collaboration. The funding sources had no involvement in the conduct of the research and/or preparation of the manuscript.

Source of Funding

This work was supported by the three Dutch care organisations, Abrona, Amarant and Ipse de Bruggen, involved in the HA-ID consortium. The funding sources had no involvement in the conduct of the research and/or preparation of the manuscript.

Conflict of Interest

The named authors have no conflict of interest, financial or otherwise.

Ethical Approval

Ethical approval was obtained from the Medical Ethics Review Committee of the Erasmus MC, University Medical Center Rotterdam (MEC-2008-234). This study follows the guidelines of the Declaration of Helsinki.

Data availability statement

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

References

Abellan Van Kan G., Rolland Y., Andrieu S., Bauer J., Beauchet O., Bonnefoy M. et al. (2009) Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) Task Force. *The Journal of Nutrition, Health & Aging* **13**, 881–9.

Abizanda P., Navarro J. L., García-Tomás M. I., López-Jiménez E., Martínez-Sánchez E. & Paterna G. (2012) Validity and usefulness of hand-held dynamometry for measuring muscle strength in community-dwelling older persons. *Archives of Gerontology and Geriatrics* **54**, 21–7.

Alberti K. G., Eckel R. H., Grundy S. M., Zimmet P. Z., Cleeman J. I., Donato K. A. et al. (2009) Harmonizing the metabolic syndrome: A joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. *Circulation* **120**, 1640–5.

American College of Sports Medicine (2021) *ACSM's guidelines for exercise testing and prescription*, 11th edn. Wolters Kluwer, Philadelphia.

Boer P. H., Meeus M., Terblanche E., Rombaut L., Wandele I. D., Hermans L. et al. (2014) The influence of sprint interval training on body composition, physical and metabolic fitness in adolescents and young adults with intellectual disability: A randomized controlled trial. *Clinical Rehabilitation* **28**, 221–31.

Boer P. H. & Moss S. J. (2016) Effect of continuous aerobic vs. interval training on selected anthropometrical, physiological and functional parameters of adults with Down syndrome. *Journal of Intellectual Disability Research* **60**, 322–34.

Bohannon R. W. (1997) Comfortable and maximum walking speed of adults aged 20-79 years: Reference values and determinants. *Age and Ageing* **26**, 15–9.

Bouzas S., Martínez-Lemos R. I. & Ayán C. (2019) Effects of exercise on the physical fitness level of adults with intellectual disability: A systematic review. *Disability and Rehabilitation* **41**, 3118–40.

Cooper S. A., Hughes-Mccormack L., Greenlaw N., Mcconnachie A., Allan L., Baltzer M. et al. (2018) Management and prevalence of long-term conditions in primary health care for adults with intellectual disabilities compared with the general population: A population-based cohort study. *Journal of Applied Research in Intellectual Disabilities* **31**, 68–81.

De Leeuw M. J., Oppewal A., Elbers R. G., Knulst M., Van Maurik M. C., Van Bruggen M. C. et al. (2022) Healthy Ageing and Intellectual Disability study: Summary of findings and the protocol for the 10-year follow-up study. *BMJ Open* **12**, e053499.

De Winter C. F., Bastiaanse L. P., Hilgenkamp T. I., Evenhuis H. M. & Echteld M. A. (2012a) Cardiovascular risk factors (diabetes, hypertension, hypercholesterolemia and metabolic syndrome) in older people with intellectual disability: Results of the HA-ID study. *Research in Developmental Disabilities* **33**, 1722–31.

De Winter C. F., Bastiaanse L. P., Hilgenkamp T. I., Evenhuis H. M. & Echteld M. A. (2012b) Overweight and obesity in older people with intellectual disability. *Research in Developmental Disabilities* **33**, 398–405.

De Winter C. F., Bastiaanse L. P., Kranendonk S. E., Hilgenkamp T. I., Evenhuis H. M. & Echteld M. A. (2013) Peripheral arterial disease in older people with intellectual disability in the Netherlands using the ankle-brachial index: Results of the HA-ID study. *Research in Developmental Disabilities* **34**, 1663–8.

De Winter C. F., Echteld M. A. & Evenhuis H. M. (2014) Chronic kidney disease in older people with intellectual disability: Results of the HA-ID study. *Research in Developmental Disabilities* **35**, 726–32.

De Winter C. F., Magilsen K. W., Van Alfen J. C., Willemsen S. P. & Evenhuis H. M. (2011) Metabolic syndrome in 25% of older people with intellectual disability. *Family Practice* **28**, 141–4.

De Winter C. F., Van Den Berge A. P., Schoufour J. D., Oppewal A. & Evenhuis H. M. (2016) A 3-year follow-up study on cardiovascular disease and mortality in older people with intellectual disabilities. *Research in Developmental Disabilities* **53-54**, 115–26.

Dunkley A. J., Tyrer F., Spong R., Gray L. J., Gillett M., Doherty Y. et al. (2017) Screening for glucose intolerance and development of a lifestyle education programme for prevention of type 2 diabetes in a population with intellectual disabilities: The STOP Diabetes research project. *NIHR Journals Library.* **5**, 1–316.

Fess E. E. & Moran C. (1981) *Clinical assessment recommendations*. American Society of Hand Therapists Monograph, Indianapolis.

Field A. (2013) *Discovering Statistics Using IBM SPSS Statistics*. SAGE Publications Ltd, London.

Flygare Wallén E., Ljunggren G., Carlsson A. C., Pettersson D. & Wändell P. (2018) High prevalence of diabetes mellitus, hypertension and obesity among persons with a recorded diagnosis of intellectual disability or autism spectrum disorder. *Journal of Intellectual Disability Research* **62**, 269–80.

Fonseca Alves D. J., Bartholomeu-Neto J., Júnior E. R., Ribeiro Zarricueta B. S., Nóbrega O. T. & Córdova C. (2017) Walking speed, risk factors, and cardiovascular events in older adults-systematic review. *Journal of Strength and Conditioning Research* **31**, 3235–44.

Hilgenkamp T. I., Bastiaanse L. P., Hermans H., Penning C., Van Wijck R. & Evenhuis H. M. (2011) Study healthy ageing and intellectual disabilities: Recruitment and design. *Research in Developmental Disabilities* **32**, 1097–106.

Hilgenkamp T. I., Van Wijck R. & Evenhuis H. M. (2012a) Feasibility and reliability of physical fitness tests in older adults with intellectual disability: A pilot study. *Journal of Intellectual & Developmental Disability* **37**, 158–62.

Hilgenkamp T. I., Van Wijck R. & Evenhuis H. M. (2012b) Low physical fitness levels in older adults with ID: Results of the HA-ID study. *Research in Developmental Disabilities* **33**, 1048–58.

Hilgenkamp T. I., Van Wijck R. & Evenhuis H. M. (2013) Feasibility of eight physical fitness tests in 1,050 older adults with intellectual disability: results of the healthy ageing with intellectual disabilities study. *Intellectual and Developmental Disabilities* **51**, 33–47.

Inker L. A., Schmid C. H., Tighiouart H., Eckfeldt J. H., Feldman H. I., Greene T. et al. (2012) Estimating glomerular filtration rate from serum creatinine and cystatin C. *The New England Journal of Medicine* **367**, 20–9.

Jansen J., Rozeboom W., Penning C. & Evenhuis H. M. (2013) Prevalence and incidence of myocardial infarction and cerebrovascular accident in ageing persons with intellectual disability. *Journal of Intellectual Disability Research* **57**, 681–5.

Kaminsky L. A., Arena R., Ellingsen Ø., Harber M. P., Myers J., Ozemek C. et al. (2019) Cardiorespiratory fitness and cardiovascular disease - The past, present, and future. *Progress in Cardiovascular Diseases* **62**, 86–93.

Lennox N. G., Diggens J. N. & Ugoni A. M. (1997) The general practice care of people with intellectual disability: Barriers and solutions. *Journal of Intellectual Disability Research* **41**, 380–90.

Myers J., Mcauley P., Lavie C. J., Despres J. P., Arena R. & Kokkinos P. (2015) Physical activity and cardiorespiratory fitness as major markers of cardiovascular risk: Their independent and interwoven importance to health status. *Progress in Cardiovascular Diseases* **57**, 306–14.

Nederlandse Hart Registratie & Hartstichting. 2022. Hart- en Vaatcijfers [Online]. Available at: https://www.nederlandsehartregistratie.nl/hartenvaatcijfers/ [Accessed June 6, 2022].

Nordstrøm M., Paus B., Retterstøl K. & Kolset S. O. (2016) The prevalence of metabolic risk factors of atherosclerotic cardiovascular disease in Williams's syndrome, Prader Willi syndrome, and Down syndrome. *Intellectual and Developmental Disabilities* **41**, 187–96.

Oppewal A., Hilgenkamp T. I., Van Wijck R. & Evenhuis H. M. (2013) Feasibility and outcomes of the Berg balance scale in older adults with intellectual disabilities. *Research in Developmental Disabilities* **34**, 2743–52.

Oppewal A., Hilgenkamp T. I., Van Wijck R., Schoufour J. D. & Evenhuis H. M. (2014) Physical fitness is predictive for a decline in daily functioning in older adults with intellectual disabilities: Results of the HA-ID study. *Research in Developmental Disabilities* **35**, 2299–315.

Oppewal A., Hilgenkamp T. I., Van Wijck R., Schoufour J. D. & Evenhuis H. M. (2015) Physical fitness is predictive for a decline in the ability to perform instrumental activities of daily living in older adults with intellectual disabilities: Results of the HA-ID study. *Research in Developmental Disabilities* **41-42**, 76–85.

Oppewal A., Maes-Festen D. & Hilgenkamp T. I. M. (2020) Small steps in fitness, major leaps in health for adults with intellectual disabilities. *Exercise and Sport Sciences Reviews* **48**, 92–7.

Ozemek C., Laddu D. R., Lavie C. J., Claeys H., Kaminsky L. A., Ross R. et al. (2018) An update on the role of cardiorespiratory fitness, structured exercise and lifestyle physical activity in preventing cardiovascular disease and health risk. *Progress in Cardiovascular Diseases* **61**, 484–90.

Patja K., Mölsä P. & Livanainen M. (2001) Cause-specific mortality of people with intellectual disability in a population-based, 35-year follow-up study. *Journal of Intellectual Disability Research* **45**, 30–40.

Reppermund S. & Trollor J. N. (2016) Successful ageing for people with an intellectual disability. *Current Opinion in Psychiatry* **29**, 149–54.

Salaun L. & Berthouze-Aranda S. E. (2012) Physical fitness and fatness in adolescents with intellectual disabilities. *Journal of Applied Research in Intellectual Disabilities* **25**, 231–9.

Singh S. J., Morgan M. D., Hardman A. E., Rowe C. & Bardsley P. A. (1994) Comparison of oxygen uptake during a conventional treadmill test and the shuttle walking test in chronic airflow limitation. *The European Respiratory Journal* **7**, 2016–20.

Singh S. J., Morgan M. D., Scott S., Walters D. & Hardman A. E. (1992) Development of a shuttle walking test of disability in patients with chronic airways obstruction. *Thorax* **47**, 1019–24.

Sinnema M., Maaskant M. A., Van Schrojenstein Lantman-De Valk H. M., Van Nieuwpoort I. C., Drent M. L., Curfs L. M. et al. (2011) Physical health problems in adults with Prader-Willi syndrome. *American Journal of Medical Genetics. Part A* **155A**, 2112–24.

Stark T., Walker B., Phillips J. K., Fejer R. & Beck R. (2011) Hand-held dynamometry correlation with the gold standard isokinetic dynamometry: A systematic review. *PM & R: The Journal of Injury, Function, and Rehabilitation* **3**, 472–9.

Steffen T. M., Hacker T. A. & Mollinger L. (2002) Age- and gender-related test performance in community-dwelling elderly people: Six-minute walk test, Berg balance scale, timed up & go test, and gait speeds. *Physical Therapy* **82**, 128–37.

Strauss D., Cable W. & Shavelle R. (1999) Causes of excess mortality in cerebral palsy. *Developmental Medicine and Child Neurology* **41**, S001216229900122X.

Thomas S., Reading J. & Shephard R. J. (1992) Revision of the physical activity readiness questionnaire (PAR-Q). *Canadian Journal of Sport Sciences* **17**, 338–45.

Tikkanen E., Gustafsson S. & Ingelsson E. (2018) Associations of fitness, physical activity, strength, and genetic risk with cardiovascular disease: Longitudinal analyses in the UK biobank study. *Circulation* **137**, 2583–91.

U.S. Department of Health and Human Services 2008. Physcial acitivity guidelines advisory committee report. Washington, Department of Health and Human Services.

Van Den Akker M., Maaskant M. A. & Van Der Meijden R. J. (2006) Cardiac diseases in people with intellectual disability. *Journal of Intellectual Disability Research* **50**, 515–22.

Van Den Bemd M., Cuypers M., Bischoff E. W. M. A., Heutmekers M., Schalk B. & Leusink G. L. (2022) Exploring chronic disease prevalence in people with intellectual disabilities in primary care settings: A scoping review. *Journal of Applied Research in Intellectual Disabilities* **35**, 382–98.

Van Eeghen A. M., Huisman S. A., Van Goethem G. & Boot E. (2019) [Somatic comorbidity in children and adults with intellectual disability and mental health problems.] Somatische comorbiditeit bij kinderen en volwassenen met een verstandelijke beperking en een psychiatrische aandoening. *Tijdschrift voor Psychiatrie* **61**, 773–8.

Veronese N., Stubbs B., Volpato S., Zuliani G., Maggi S., Cesari M. et al. (2018) Association between gait speed with mortality, cardiovascular disease and cancer: A systematic review and meta-analysis of prospective cohort studies. *Journal of the American Medical Directors Association* **19**, 981–8.

Visseren F. L. J., Mach F., Smulders Y. M., Carballo D., Koskinas K. C., Bäck M. et al. (2021) 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice: Developed by the Task Force for cardiovascular disease prevention in clinical practice with representatives of the European Society of Cardiology and 12 medical societies with the special contribution of the European Association of Preventive Cardiology (EAPC). *European Heart Journal* **42**, 3227–337.

Wagemans, A. (2013). The process of end-of life decisions regarding people with intellectual disabilities [Online]. Available at: https://www.kennispleingehandicaptensector.nl/images/KGS/images/Nieuws/2018/palliatieve-zorg-proefschrift-process-end-of-live-decisions.pdf [Accessed June 6, 2022].

World Health Organization(1996). ICD-10 guide for mental retardation, Geneva, World Health Organization.

World Health Organization (2021). Cardiovascular diseases. Geneva, World Health Organization.

World Medical Association. (2013). WMA Declaration of Helsinki - Ethical principles for medical research involving human subjects, 64th WMA General Assembly, Fortaleza, Brazil. 2013 [Online]. Available at: https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/ [Accessed June 6, 2022].

Wu Y., Wang W., Liu T. & Zhang D. (2017) Association of grip strength with risk of all-cause mortality, cardiovascular diseases, and cancer in community-dwelling populations: A meta-analysis of prospective cohort studies. *Joural of the American Medical Directors Association* **18**, 551.e17–e35.

Accepted 22 February 2023