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Ideal cardiovascular health and its association with sedentary behaviour and fitness in psychiatric patients. The PsychiActive project

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Abstract *Background and aims:* Ideal cardiovascular health (CVH) was defined as meeting ideal levels of 4 health behaviours (smoking, body mass index, physical activity, and diet) and 3 biological factors (blood pressure, total cholesterol, and glucose) and is inversely related to cardiovascular disease and mortality. However, the prevalence of ideal CVH in patients with severe mental illness and the possible independent associations of sedentary behaviour and fitness with CVH score are unexplored.

Methods and results: This study included 142 (34 women) outpatients with severe mental illness (primarily schizophrenia, n = 92). CVH was evaluated according to the American Heart Association guidelines. Sedentary behaviour, cardiorespiratory fitness, and muscular strength were measured by an activity-monitor, the 6-min walk test, and handgrip dynamometry. Cardiorespiratory fitness and strength values were combined in a composite fitness score. The prevalence of ideal CVH was: non-smoking (47.9%), body mass index (16.9), physical activity (83.1%), diet (10.4%), blood pressure (40.4%), total cholesterol (62.9%), and plasma glucose (66.7%). Low levels of sedentary behaviour and high cardiorespiratory, strength, and composite fitness score were associated with meeting the ideal threshold in most CVH metrics and having higher global CVH score; however, only cardiorespiratory and composite fitness score remained significantly related to global CVH score independent of sedentary behaviour and multiple confounders.

Conclusions: Patients with severe mental illness generally have low prevalence of ideal CVH metrics, especially diet and body mass index. Additionally, our findings suggest the need or considering cardiorespiratory fitness, regardless of sedentary behaviour, to promote ideal CVH in this population.

Introduction

Cardiovascular disease is a leading cause of death worldwide and poses substantial social, economic and health burdens. Compared to the general population, patients with severe mental illness (SMI) have an increased risk of mortality due to cardiovascular disease [1]. These findings

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sustain that public health efforts to reduce the burden of cardiovascular disease risk factors have not been effective in the SMI population, thus highlighting the need for better prevention and treatment strategies.

In 2010, the American Heart Association proposed a seven-item tool including health behaviours (smoking, body mass index, physical activity, and diet) and biological factors (blood pressure, total cholesterol, and glucose) to promote ideal cardiovascular health (CVH) [2]. Several studies [3] have reported the prevalence of ideal CVH metrics in clinical and non-clinical populations and its negative association with cardiovascular and non-cardiovascular morbidity-mortality. However, no study is available on ideal CVH in patients with SMI to advance the development of effective intervention strategies.

A plethora of evidence strongly indicates that high sedentary behaviour (SB) [4] and low fitness [5] levels are predictors of all-cause and cardiovascular mortality, independent of physical activity level and other confounders. However, there is insufficient evidence on the association of SB [6,7] and fitness [8–10] with ideal CVH, and the independent association of both exposures with ideal CVH remain unexplored. Patients with SMI have higher SB [11] and lower fitness [12] levels than controls, and although some studies (e.g., [13,14]) have explored their association with CVH outcomes, their independent role has received little attention. Therefore, increasing knowledge of the impact of sedentary behaviour and fitness on the ideal CVH could help raise awareness among policy makers, practitioners, researchers, and the general public about the importance of maintaining an active lifestyle for health. The aims of this study were (i) to examine the prevalence of ideal CVH in patients with SMI and (ii) to explore the possible associations and independent associations of SB and fitness with ideal CVH score.

Methods

Study design and participants

From July 2014 to July 2017, all patients from 14 different outpatient mental healthcare settings in southern Spain were invited to participate. Project pamphlets and posters were placed in waiting rooms, and interested people contacted the researchers directly or through staff members. A convenience sample of adults with a range of established ICD-10 SMI diagnoses (see Table 1), stabilized on antipsychotic medication during the last month were included in this study. Patients with clinical instability, substance abuse, or comorbidities contraindicating participation were excluded. Participants were required to undergo anthropometric, fitness, and blood measurements, wear an activity monitor, and complete questionnaires about sociodemographic characteristics as well as smoking, diet, and symptomatology severity. Personal medical records were also reviewed. The study procedure was approved by the Hospitales Universitarios Vírgen Macarena and Virgen del Rocío Ethics Committee (1674-N-17). All patients gave their informed written consent prior

Table 1 Characteristics of the participants (n = 142).

Variables	Values
Age (years)	41.4 ± 9.1
Body mass (kg)	88.8 ± 17.8
Height (cm)	171.6 ± 8.3
Body mass index (kg/m^2)	30.1 ± 5.7
Sedentary behaviour (min/day, % of waking time/day)[a]	540 ± 138 (58.8)
6-min walk test (m)[a]	600.9 ± 102.4
Handgrip strength (kg)	42.8 ± 10.9
Relative handgrip strength (strength/body mass, both in kg)	0.49 ± 0.13
Systolic blood pressure (mm Hg)[a]	121.4 ± 15.9
Diastolic blood pressure (mm Hg)[a]	79.4 ± 10.6
Glucose (mg/dL)[a]	101.2 ± 32.3
Total cholesterol (mg/dL)[a]	192.3 ± 33.3
Adherence to Mediterranean diet (0–14)[a,b]	6.7 ± 2.2
Moderate-vigorous physical activity (min/week)[a,c]	570.1 ± 509.2
Psychopathological severity (0–72)[d]	15.6 ± 13.1
Chlorpromazine equivalent dose (mg/day)[a]	573.7 ± 565.0
Illness duration (years)[a]	15.6 ± 9.1
Gender (women)	34 (23.9)
Smoking (current smoker)	74 (52.1)
Race (Caucasian)	142 (100)
Diagnoses[a]	
Schizophrenia, schizotypal and delusional disorders	92 (67.2)
Mood [affective] disorders	27 (19.7)
Disorders of adult personality and behaviour	9 (6.6)
Neurotic, stress-related and somatoform disorders	5 (3.6)
Mental retardation	2 (1.5)
Disorders due to psychoactive substance use	2 (1.5)
Marital status[a]	
Married	10 (7.3)
Unmarried	111 (81.0)
Separated/divorced	16 (11.7)
Educational status[a]	
Primary school or less	71 (53.4)
Secondary school or more	62 (46.6)
Occupational status[a]	
Working	22 (16.3)
Unemployed	43 (31.9)
Retired	70 (51.9)

NOTE. Values are the mean ± SD or n (%).

[a] Missing data. Reasons: Refusal to wear the SenseWear to assess physical and sedentary behaviours (n = 8) and to undergo blood glucose and cholesterol determinations (n = 66); unregistered data attributed to technical problems to assess physical and sedentary behaviours (n = 3), blood pressure (n = 1), and cholesterol (n = 6); unmet SenseWear wear-time criteria to assess physical and sedentary behaviours (n = 13); incomplete 6-min walk test (n = 1); incomplete patient medical record data for diagnoses, illness duration, chlorpromazine equivalent dose (n = 5, 16 and 17, respectively); and incomplete questionnaire data for adherence to the Mediterranean diet (n = 17), psychopathological severity (n = 13), marital (n = 5), educational (n = 9), and occupational status (n = 7).

[b] Adherence to the Mediterranean diet was assessed using the 14-Item Mediterranean Diet Tool, with higher scores indicating a high adherence.

[c] Moderate-vigorous physical activity accumulated in bouts of ≥10 min.

[d] Psychopathological severity was assessed using the Brief Symptoms Inventory-18, with higher scores indicating greater severity.

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to enrolling in the study and after receiving information about the aims and protocol. There was no compensation for participation.

Ideal CVH

Health behaviours

Smoking was self-reported, and patients classified as non-smokers were categorized as having an ideal smoking status. Body mass index was calculated using weight and height measured to the nearest 0.1 kg and 0.1 cm using a scale (TANITA BC-420; Tanita, Tokyo, Japan) and a stadiometer, respectively, and ideal body mass index was considered <25 kg/m^2. Ideal diet was defined as high adherence to the Mediterranean diet, which has been proven to be protective in terms of morbi-mortality [15], instead of the ideal diet concept that was originally proposed [2]. To classify individuals with high adherence, we used a score $\geq$10 in the 14-Item Mediterranean Diet Tool [16] as previously considered [16,17]. Physical activity was measured objectively with the SenseWear Pro3 Armband (BodyMedia, Inc., Pittsburgh, PA, USA), a multisensory-activity monitor that uses manufacturer-specific algorithms (SenseWear Professional software version 8.1; BodyMedia, Inc., Pittsburgh, PA, USA) to estimate energy expenditure. Patients were required to wear this device on their left arm triceps muscle for nine consecutive days, 24 h/day, except when showering or swimming, and were asked to follow their usual lifestyle. The first and last days were excluded from the analysis to minimize reactivity. Seven days with a minimum registration of 1368 min/day (95% of a 24-h period) were necessary to be included in the analysis, as previously considered in this population [13]. Ideal physical activity was considered $\geq$150 min/week of moderate-to-vigorous physical activity ($>$3.0 metabolic equivalents) accumulated in bouts of $\geq$10 min.

Biological factors

The following *factors* were collected by trained staff in the morning after an overnight fast. Blood pressure was measured in a seated position after a 10-min rest period with a wrist-monitor (HEM-6221-E, Omron Healthcare Europe BV, Hoofddorp, the Netherlands) placed on the left arm. The mean of two measures was used for analysis. If the two measures differed by $\geq$20 mm Hg for systolic and $\geq$10 mm Hg for diastolic blood pressure, a third measurement was taken, and the median of the three measurements was used. Ideal blood pressure was considered $<$120 mmHg systolic and $<$80 mmHg diastolic. Total cholesterol $<$200 mg/dL and glucose concentrations $<$100 mg/dL were considered ideal.

CVH score

According to American Heart Association criteria [2], global (ranging from 0 to 7), behavioural (0–4), and biological (0–3) CVH scores were computed as the sum of the metrics, in which the ideal threshold was met (i.e., 1 point for each).

SB

SB (min/day), considered any waking activity with an energy expenditure $\leq$1.5 metabolic equivalents, was obtained from the same dataset under the same requirements used for physical activity measurement.

Fitness

Cardiorespiratory fitness (CRF) was assessed by the 6-min walk test according to Rikli and Jones [18] on an indoor course with a flat, firm surface and with minimal external stimuli. Patients were instructed to walk as far as possible during a 6-min period around a 45.7-m rectangular course delimited by cones, without running or jogging. Resting was allowed if necessary, but walking was to be resumed as soon as possible. Standardized encouragements were used, as recommended [18]. The same trained instructor explained the protocol, gave a demonstration prior to start, supervised the test and recorded the total distance walked to the nearest 0.1 m for each patient. A multimedia explanation is available on the link below: https://upotv.upo.es/video/5936500f238583f9658b464a.

Muscular strength (MS) was assessed to the nearest 0.1 kg with a hand dynamometer (TKK 5401 Grip-D, Takey, Tokyo, Japan). Patients in erect stance and with the arm in complete extension were instructed to squeeze the handle as fast and as hard as possible for 5 s while receiving verbal encouragement. The test was performed twice (alternately with both hands) with a 1-min rest between trials, and the maximum value of the four attempts was used. To account for individual differences in body mass, we have used relative grip strength (i.e., handgrip strength/body mass, both in kg) for the analysis.

Additionally, a composite fitness score was constructed by averaging the standardized values of distance walked during the 6-min test and relative handgrip strength. Scores above zero represent a higher fitness level.

Sociodemographic characteristics and other clinical data

Marital, educational, and occupational status were self-reported. Age, diagnosis, illness duration, and medication were obtained from the patients' medical records. Antipsychotic medication was converted into chlorpromazine equivalent dose [19]. The Global Severity Index of the Brief Symptoms Inventory-18 [20] was used to assess psychopathological severity over the past week. Illness duration, chlorpromazine equivalent dose and psychopathological severity will be referred to as 'illness-related-factors' henceforth.

Statistical analysis

The proportion of ideal CVH metrics was calculated overall and for groups, stratified by gender, by high or low levels according to age and single illness-related-factors using median splits. Chi-square and Fisher exact tests were applied to examine differences in the proportion of ideal

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CVH metrics. Differences in SB and fitness levels between ideal and non-ideal CVH metrics were assessed by analysis of covariance, with the aforementioned variables as dependent variables, CVH metric (ideal vs. non-ideal) entered as a fixed factor, and age and gender as covariates. The analysis of covariance was repeated adding illness-related-factors, as covariates. Multiple linear regression analysis, including patients with complete data on the seven CVH metrics, was used to examine the associations of SB and fitness levels, with CVH scores adjusted for gender and age. Furthermore, SB and fitness outcomes, as applicable, were added to the models. When exploring the role of the behavioural and biological CVH scores, the analysis was also adjusted for the status (ideal or non-ideal) of the rest metrics (analysis without this adjustment is available as supplemental material 1). The regression analysis was repeated including education and illness-related factors in the models. Residuals were tested for homoscedasticity, linearity and independence. The variance inflation factor never exceeded three, indicating that multi-collinearity was not a concern. Data were analysed using SPSS Statistics for Windows, Version 22.0 (Armonk, NY: IBM Corp), with statistical significance set at $\alpha = 0.050$.

Results

One hundred forty-two patients with SMI aged between 18 and 61 years participated, and their characteristics are summarized in Table 1. The prevalence of ideal CVH metrics stratified by gender, age, and illness-related-factors are presented in Table 2. Most had ideal physical activity levels (83.1%), whereas less than 20% had ideal body mass index (16.9%) and diet (10.4%). More than half of the patients had ideal glucose (66.7%) and cholesterol (62.9%) levels, whereas less than half had an ideal smoking status (47.9%) and blood pressure (40.4%). Compared with their counterparts, men had a lower prevalence of ideal blood pressure and glucose, the older age group had a lower prevalence of ideal blood pressure, and those with high chlorpromazine equivalent dose had a lower prevalence of ideal smoking status (all $P < 0.050$).

Table 3 shows sedentary behaviour and fitness estimates by ideal CVH metrics. Levels of SB were lower in those who met ideal CVH metrics (all $P \leq 0.01$), except for smoking status and diet. After adding illness-related-factors as covariates, the differences remained significant (all $P < 0.050$; data not shown). Levels of CRF were higher in those who met ideal body mass index, physical activity, diet, and blood pressure (all $P < 0.050$). After adding illness-related-factors as covariates, differences in body mass index and diet became non-significant ($P = 0.074$ and $P = 0.166$, respectively; data not shown), and differences in smoking status became significant ($P = 0.013$; data not shown). Levels of MS were higher in those who met ideal body mass index, cholesterol, and blood pressure (all $P < 0.050$). After adding illness-related-factors as covariates, the differences remained significant (all $P < 0.050$; data not shown), except for cholesterol ($P = 0.151$; data not shown). Composite fitness scores were higher in those who met ideal CVH metrics (all $P < 0.050$), except for smoking, diet, and glucose. After adding illness-related-factors as covariates, the differences remained significant (all $P < 0.050$; data not shown).

Among the 54 patients (43 men, 38 with schizophrenia, mean [range] age 41.5 ± 8.6 [18–59] years) with complete data on the seven CVH metrics, only one individual had 0 of the 7 ideal metrics, 42 (77.7%) had <5, and none had all 7 ideal CVH metrics. The results of the multivariate analysis to explore the associations of SB and fitness with CVH scores are shown in Table 4. Lower levels of SB were associated with higher global ($\beta = -0.41$, $P = 0.002$) and biological ($\beta = -0.37$, $P = 0.014$) CVH scores (Table 4). After adding the composite fitness score to the model, the associations were non-significant. Higher levels of CRF were associated with higher global ($\beta = 0.55$, $P < 0.001$) and behavioural ($\beta = 0.74$, $P < 0.001$) CVH scores. After adding SB and MS to the model, the associations remained significant. Higher levels of MS were associated with higher global ($\beta = 0.43$, $P = 0.004$) and biological ($\beta = 0.40$, $P = 0.025$) CVH scores. After adding SB and CRF to the model, these results became nonsignificant. Higher composite fitness scores were associated with higher global ($\beta = 0.59$, $P < 0.001$) and behavioural ($\beta = 0.67$, $P < 0.001$) CVH scores. After adding SB to the model, both associations remained significant. When adding education and illness-related-factors to the models, all results remained unchanged, except for the association between MS and the ideal biological CVH score, which became non-significant (data not shown).

Discussion

Overall, the prevalence of ideal CVH metrics in patients with SMI was low. More than three-quarters of patients with complete data had sub-optimal CVH scores, with less than 5 of the 7 ideal CVH metrics, which is concerning because this score is associated with a higher risk of all-cause and cardiovascular mortality [3]. Additionally, although low SB, high CRF, and high MS levels are associated with meeting the ideal threshold in most CVH metrics and having higher global, behavioural, and biological CVH scores, only CRF remained significantly related to global CVH score, independent of SB and multiple confounders. These findings suggest that CRF has a stronger influence on CVH than SB or MS.

Taking into account that prevalence of ideal CVH metrics seems to vary by the country's socioeconomic status [3] due to sociocultural background and healthcare system differences, our prevalence data in patients with SMI were mainly compared to normative data from the healthy adult Spanish population [21]. The prevalence of ideal body mass index and physical activity among our population are lower and higher, respectively, than that among Spanish controls aged between 18 and 64 years [21], with the remaining metrics being practically similar, and healthy diet being the least prevalent. The poor levels of ideal body mass index and diet can be expected because overweight

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Table 2 Prevalence of American Heart Association ideal cardiovascular health metrics in patients with severe mental illness.

	Ideal health behaviours								Ideal biological measures					
	Non-smoking		Body mass index		Physical activity		Healthy diet		Blood pressure		Total cholesterol		Glucose	
	n[a]	% ideal (95% CI)	n[a]	% ideal (95% CI)	n[a]	% ideal (95% CI)	n[a]	% ideal (95% CI)	n[a]	% ideal (95% CI)	n[a]	% ideal (95% CI)	n[a]	% ideal (95% CI)
All	142	47.9 (39.8–56.1)	142	16.9 (11.6–23.9)	118	83.1 (75.3–88.8)	125	10.4 (6.2–17.0)	141	40.4 (32.7–48.7)	70	62.9 (51.1–73.2)	75	66.7 (55.4–76.3)
Gender														
Men	108	44.4 (35.4–53.8)	108	17.6 (11.6–25.8)	94	86.2 (77.8–91.7)	94	9.6 (5.1–17.2)	107	35.5 (27.1–44.9)	55	63.6 (50.4–75.1)	59	61.0 (48.3–72.4)
Women	34	58.8 (42.2–73.6)	34	14.7 (6.4–30.1)	24	70.8 (50.8–85.1)	31	12.9 (5.1–28.9)	34	55.9 (39.5–71.1)	15	60.0 (35.7–80.2)	16	87.5 (64.0–96.5)
P	0.143		0.695		0.123		0.735		0.035		0.796		0.046	
Age														
18–41 years	73	47.9 (36.9–59.2)	73	17.8 (10.7–28.1)	62	77.4 (65.6–86.0)	67	11.9 (6.2–21.8)	73	49.3 (38.2–60.5)	31	74.2 (56.8–86.3)	35	77.1 (61.0–87.9)
42–61 years	69	47.8 (36.5–59.4)	69	15.9 (9.1–26.3)	56	89.3 (78.5–95.0)	58	8.6 (3.7–18.6)	68	30.9 (21.2–42.6)	39	53.8 (38.6–68.4)	40	57.5 (42.2–71.5)
P	0.989		0.767		0.086		0.544		0.026		0.080		0.072	
Psychopathological severity[b]														
0–12	64	43.8 (32.3–55.9)	64	15.6 (8.7–26.4)	52	88.5 (77.0–94.6)	61	14.8 (8.0–25.7)	64	43.8 (32.3–55.9)	32	65.6 (48.3–79.6)	33	69.7 (52.7–82.6)
13–57	65	47.7 (36.0–59.6)	65	16.9 (9.7–27.8)	59	76.3 (64.0–85.3)	58	6.9 (2.7–16.4)	65	35.4 (24.9–47.5)	33	63.6 (46.6–77.8)	35	60.0 (43.6–74.4)
P	0.653		0.842		0.095		0.170		0.331		0.867		0.403	
Illness duration														
1–14 years	62	43.5 (31.9–55.9)	62	19.4 (11.4–30.9)	56	76.8 (64.2–85.9)	55	12.7 (6.3–24.0)	62	45.2 (33.4–57.5)	33	63.6 (46.6–77.8)	35	62.9 (46.3–76.8)
15–43 years	64	46.9 (35.2–58.9)	64	15.6 (8.7–26.4)	51	88.2 (76.6–94.5)	57	8.8 (3.8–18.9)	64	37.5 (26.7–49.7)	34	61.8 (45.0–76.1)	36	66.7 (50.3–79.8)
P	0.708		0.581		0.122		0.499		0.383		0.874		0.737	
Chlorpromazine equivalent dose														
0–450 mg/day	63	57.1 (44.9–68.6)	63	22.2 (13.7–33.9)	52	78.8 (66.0–87.8)	53	15.1 (7.9–27.1)	63	46.0 (34.3–58.2)	33	63.6 (46.6–77.8)	35	68.6 (52.0–81.4)
480–3000 mg/day	62	37.1 (26.2–49.5)	62	12.9 (6.7–23.4)	52	82.7 (70.3–90.6)	57	7.0 (2.8–16.7)	62	35.5 (24.7–47.9)	29	65.5 (47.3–80.1)	30	56.7 (39.2–72.6)
P	0.025		0.171		0.619		0.175		0.230		0.877		0.321	

NOTE. Chi square test was used to examine differences in the proportion of ideal CVH metrics, except to compare the proportion of ideal physical activity and diet between genders. Fisher's exact test was used in these two cases.
Significant when $P < 0.050$.

[a] n varies due to missing data. Reasons: Refusal to wear the SenseWear to assess physical activity (n = 8) and to undergo blood glucose and cholesterol determinations (n = 66); unregistered data attributed to technical problems to assess physical activity (n = 3), blood pressure (n = 1), and cholesterol (n = 6); unmet the SenseWear wear-time criteria to assess physical activity (n = 13); incomplete patient medical record data for illness duration and chlorpromazine equivalent dose (n = 16 and 17, respectively); and incomplete questionnaire data for psychopathological severity (n = 13).

[b] Psychopathological severity was assessed using the Brief Symptoms Inventory-18, with higher scores indicating greater severity.

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Table 3 Sedentary behaviour and fitness estimates by ideal cardiovascular health metrics in patients with severe mental illness.

	Sedentary behaviour (min/day)		6-min walk test (m)		Relative handgrip strength[a]		Composite fitness score[b]	
	N (%)	Values	N (%)	Values	N (%)	Values	N (%)	Values
Smoking								
Ideal	55 (47)	534 ± 144	67 (48)	612.6 ± 105.2	68 (48)	0.48 ± 0.12	67 (48)	0.01 ± 0.85
Non-ideal	63 (53)	534 ± 144	74 (52)	590.4 ± 99.4	74 (52)	0.51 ± 0.13	74 (52)	0.00 ± 0.90
P[c]		0.999		0.075		0.549		0.381
Body mass index								
Ideal	18 (15)	414 ± 144	24 (17)	649.6 ± 113.6	24 (17)	0.62 ± 0.11	24 (17)	0.73 ± 0.85
Non-ideal	100 (85)	558 ± 132	117 (83)	591.0 ± 97.5	118 (83)	0.47 ± 0.12	117 (83)	−0.14 ± 0.81
P[c]		<0.001		0.010		<0.001		<0.001
Physical activity								
Ideal	98 (83)	516 ± 138	98 (84)	615.1 ± 104.1	98 (83)	0.51 ± 0.13	98 (84)	0.15 ± 0.87
Non-ideal	20 (17)	624 ± 138	19 (16)	554.6 ± 72.0	20 (17)	0.44 ± 0.14	19 (16)	−0.40 ± 0.77
P[c]		0.002		0.012		0.097		0.031
Diet								
Ideal	12 (11)	504 ± 96	13 (10)	644.2 ± 69.1	13 (10)	0.49 ± 0.10	13 (10)	0.19 ± 0.67
Non-ideal	93 (89)	546 ± 144	112 (90)	596.8 ± 105.1	112 (90)	0.49 ± 0.13	112 (90)	−0.02 ± 0.90
P[c]		0.222		0.035		0.830		0.169
Blood pressure								
Ideal	51 (44)	498 ± 138	57 (41)	624.2 ± 97.4	57 (40)	0.53 ± 0.14	57 (41)	0.27 ± 0.93
Non-ideal	66 (56)	564 ± 144	83 (59)	586.8 ± 102.9	84 (60)	0.47 ± 0.11	83 (59)	−0.17 ± 0.80
P[c]		0.006		0.003		<0.001		<0.001
Total cholesterol								
Ideal	40 (64)	480 ± 138	43 (62)	622.8 ± 84.9	44 (63)	0.52 ± 0.13	43 (62)	0.24 ± 0.78
Non-ideal	23 (36)	588 ± 132	26 (38)	592.2 ± 95.1	26 (37)	0.46 ± 0.11	26 (38)	−0.19 ± 0.78
P[c]		0.005		0.245		0.037		0.032
Glucose								
Ideal	44 (66)	492 ± 132	50 (68)	604.6 ± 85.8	50 (67)	0.49 ± 0.14	50 (68)	0.02 ± 0.83
Non-ideal	23 (34)	576 ± 144	24 (32)	615.8 ± 96.2	25 (33)	0.51 ± 0.10	24 (32)	0.18 ± 0.69
P[c]		0.010		0.848		0.749		0.915

NOTE. Values are the mean ± SD.
Significant when $P < 0.050$.
[a] Handgrip strength/body mass, both in kg.
[b] Constructed by averaging the standardized values of distance walked during the 6-min test and relative handgrip strength. Scores above zero represent higher fitness level.
[c] From analysis of covariance with gender and age as covariates.

and unhealthy diet are two well-known critical health issues in patients with SMI [22]. However, the rate of ideal physical activity (83.1%) was remarkably high compared to Spanish controls [21], which was based upon self-report measures and ranged from 33.7% to 49.4%, and with recent global data on self-reported (54.5%) and objective (57.0%) physical activity in patients with SMI [11]. This result may be because patients who agreed to participate are those who are aware of the importance of having an active lifestyle. Furthermore, although participants were asked to follow their usual lifestyle while wearing the activity monitor, and reactivity was minimized, our data were not exempt from influence by social desirability and reactivity. Nonetheless, while most patients were physically active, they were also highly sedentary (approximately 60% of waking hours), indicating that both physical activity and SB should be considered. Taking these findings together, developing optimal strategies for healthy eating, weight loss, and adopting a less sedentary lifestyle should be a major treatment focus to prevent or delay cardiovascular disease in patients with SMI.

According to the stratified groups, women most frequently had ideal blood pressure and glucose, and younger participants most commonly had ideal blood pressure, concurring with normative data from industrial and high-income Western European countries, such as Spain [21], France [23], and Italy [24]. However, the higher prevalence of ideal glucose in women seems to contradict global meta-analysis data [25], reporting that women with SMI had a higher risk for developing hyperglycaemia. One explanation for our findings may be because men had a higher systolic blood pressure than women (mean 125 vs. 115 mm Hg, respectively, $P = 0.023$; data not shown), a well-established predisposing factor for hyperglycaemia [26]. Finally, the higher smoking prevalence in patients with higher chlorpromazine equivalent dose may be explained, even when still controversial, by the postulation that smoking is a form of self-medication for the side effects of antipsychotics [27]. Altogether, younger, women, and those taking less antipsychotics seemed to have a better CVH profile among patients with SMI.

Because no study has accounted for SB and fitness simultaneously when exploring associations with ideal CVH, our results can be compared only with studies including one of the two exposures. At present, only two studies [6,7] have examined the association of ideal CVH

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Table 4 Standardized regression coefficients (β) of sedentary behaviour and fitness for cardiovascular health scores[a] among patients with severe mental illness (n = 54).

		Global CVH score		Behavioural CVH score[b]		Biological CVH score[c]	
		β	*P*	β	*P*	β	*P*
SB	M1	−0.41	0.002	−0.19	0.227	−0.37	0.014
	M1 + CFS[d]	−0.19	0.171	0.07	0.635	−0.31	0.062
CRF	M1	0.55	<0.001	0.74	<0.001	0.15	0.460
	M1 + SB + MS	0.45	0.002	0.78	<0.001	0.00	0.989
MS	M1	0.43	0.004	0.27	0.125	0.40	0.025
	M1 + SB + CRF	0.03	0.859	−0.15	0.370	0.24	0.280
CFS[d]	M1	0.59	<0.001	0.67	<0.001	0.37	0.067
	M1 + SB	0.48	0.003	0.70	<0.001	0.20	0.345

NOTE. M1 is adjusted for gender and age.
Abbreviations: CFS: composite fitness score; CRF: cardiorespiratory fitness; CVH: cardiovascular health; M1: model 1; MS: muscular strength; SB: sedentary behaviour.
Significant when $P < 0.050$.
[a] According to American Heart Association criteria, the global (ranging from 0 to 7), behavioural (0–4), and biological (0–3) cardiovascular health scores were computed as the sum of the metrics, in which the ideal threshold was met (i.e., 1 point for each).
[b] Adjusted for status (ideal/non-ideal) of blood pressure, total cholesterol, and glucose.
[c] Adjusted for status (ideal/non-ideal) of smoking, body mass index, physical activity, and diet.
[d] Constructed by averaging the standardized values of CRF (measured as distance walked during the 6-min test) and MS (measured as handgrip strength/body mass). Scores above zero represent a higher fitness level.

and SB—one [6] in adolescents and the other [7] in the general adult population with similar age as our participants—using self-reported SB in both cases, and three studies [8–10] have examined the association of ideal CVH and fitness—one [9] in children and adolescents (using MS assessed by handgrip dynamometry), another [8] in adolescents (using CRF assessed by the 20-m shuttle-run test), and the remaining [10] in older community-dwelling adults (using global and individual scores of the Short Physical Performance Battery tests: walking speed, leg strength, and standing balance). Despite the different measurement methods and age samples used in the aforementioned studies, low SB and high fitness levels were separately related to a favourable CVH profile, which is in agreement with our results.

Finally, our results suggest that fitness remains related to global CVH score independently of SB, possibly because fitness seems to be a stronger and more-informative CVH factor than lifestyle behaviours, such as physical activity and SB in patients with SMI [14] and in the general population [5]. Although we showed that the association between MS and global CVH score became non-significant after adjusting for CRF, healthcare system should include a focus on improving both MS and CRF to reduce all-cause and cardiovascular mortality, as has been recently and consistently reported in a prospective study of >1.5 million adults [28].

This study presents some novelties and strengths. This is the first study to explore ideal CVH in patients with SMI and to examine the independent association of SB and fitness with CVH score. The main strength is the strict criteria for measuring physical activity and SB. All patients wore the activity monitor for seven consecutive days for at least 1368 min/day (95% of a 24-h period) of registered time, and reactivity was minimized. To the best of our knowledge, only four studies [8,29–31] on ideal CVH, of which two [29,30] were conducted on adults, have objectively measured physical activity, and none have objectively measured SB. Limitations include the relatively small convenience sample of outpatients, predominantly men diagnosed with schizophrenia, whose sample size varied due to missing data about the CVH metrics (specified in Table 1). Only 54 (38%) of the 142 participants had complete ideal CVH data, which may introduce bias; however, no significant differences were found between those who had complete ideal CVH data and those who had missing components in age, gender, and illness-related factors, sedentary behaviour, CRF, and MS (data not shown). These limitations may affect the generalizability of the study results. The cross-sectional design precludes causal relationships. Although the absence of a control group can be considered a limitation, we compared our data against healthy adult normative data from Spain and other similar European countries and against all published studies that have examined the association of SB and fitness with CVH score, each of which is based on observations from hundreds of healthy individuals. Nevertheless, studies including a control group are required to confirm or refute our findings. SB may have included standing, as the SenseWear cannot determine posture. However, despite including a biaxial-accelerometer, it may resolve limitations presented by triaxial-accelerometers and inclinometers through heat production measurements and placement on the upper arm. The SB measurement did not allow examining the associations of specific SBs, such as television viewing, with ideal CVH in patients with SMI, and research utilizing appropriate questionnaires [32] is needed. Although the 6-min walk test is of limited utility for individual patients, it can be used to accurately estimate mean peak oxygen uptake, the gold standard for assessing CRF, among groups of deconditioned patients [33] such as patients with SMI [12]. The handgrip test characterizes only upper-limb MS, and future studies should consider lower-limb MS and the

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combination of both to characterize overall MS. Finally, the composite fitness score is sample-specific and based on the assumption that each fitness parameter is weighted equally.

In conclusion, patients with SMI generally have a low prevalence of ideal CVH metrics, especially for diet and body mass index, and a low global CVH score, both being associated with high SB and low CRF and MS. Our study further found that higher CRF levels were directly related to a higher CVH score independently of SB, MS and multiple confounders. Altogether, we suggest that adults with SMI would benefit less from strategies directed only at reducing SB in terms of CVH. Longitudinal studies, especially interventions with well-sampled randomized controlled trials investigating changes in SB, CRF, and MS measured objectively, are necessary to gain better insights into their interrelationships with ideal CVH.

Declarations of interest

None.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.numecd.2018.05.003.

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