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Obsessive-compulsive personality disorder increases cognitive inflexibility in people with coronary artery disease

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ABSTRACT

Background: Cardiovascular diseases such as coronary artery disease (CAD) have a high prevalence of psychiatric comorbidities, that may impact clinically relevant outcomes (e.g., cognitive impairment and executive dysfunction). Obsessive-compulsive personality disorder (OCPD) is a common psychiatric comorbidity in CAD. It has a distinct cognitive profile characterised by inflexible thinking and executive dysfunction, which in turn may affect treatment adherence. However, the impact of OCPD on cognitive functioning in CAD is under-researched. We aimed to investigate the impact of OCPD on executive function in individuals with CAD undergoing rehabilitation, using cognitive tests relating to inflexibility and executive planning.

Methods: Seventy-eight adults (median age 59 [53.0–66.0] years) with CAD were tested within three days of hospital admission for cardiac rehabilitation occurring within two weeks of experiencing an episode of unstable angina or myocardial infarction. The Compulsive Personality Assessment Scale (CPAS) was used to evaluate OCPD traits. Neurocognitive testing was performed using the Cambridge Automated Neuropsychological Test Battery (CANTAB) including tests of set shifting (Intra-Extra Dimensional [IED] Set Shifting), and executive planning (Stockings of Cambridge [SOC]).

Results: Ten individuals with CAD fulfilled the operational criteria for DSM-5 OCPD. Individuals with comorbid OCPD made more IED intra-dimensional shift reversal errors (2.0 [2.0–4.0] vs. 1.0 [1.0–2.0], $p = .004$), reflecting a difficulty inhibiting previously learnt responses. When all participants were analysed as a group, negative associations were found between individual OCPD traits and other aspects of cognitive performance. Hoarding trait was associated with increased initial thinking time on the SOC at five moves ($\rho = 0.242$, $p = .033$), while the need for control and rigidity traits were each associated with increased initial thinking time on the SOC at two moves (respectively, $\rho = 0.259$, $p = .022$; $\rho = 0.239$, $p = .035$), reflecting slower executive planning. A preoccupation with details trait was associated with fewer errors on a compound discrimination stage of the IED ($\rho = -0.251$, $p = .026$). After controlling these correlations for gender and age, significant associations remained with hoarding ($\beta = 0.243$, $p = .036$), need for control ($\beta = 0.341$, $p = .005$) and rigidity ($\beta = 0.259$, $p = .038$) traits.

Conclusions: Preliminary evidence suggests that individuals with CAD and comorbid OCPD traits show greater inflexibility than those without OCPD. Several OCPD traits were associated with slower planning, even after controlling them for age and gender. This may have implications for the success of rehabilitation.

1. Introduction

Cardiovascular diseases such as coronary artery disease (CAD) are the most common causes of worsening health and death worldwide [1,2]. CAD leads to a poorer health-related quality of life and related disability [3]. Cardiovascular diseases are also a risk factor for cognitive

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impairment [4,5]. Individuals with CAD are at a greater risk of global cognition deficits [5], poorer executive functioning [6,7], and dementia [8–12]. Cognitive decline is usually related to changes in cardiovascular conditions, such as limited blood flow to the brain [13].

CAD is highly correlated with psychiatric comorbidities such as depression [14,15] and anxiety [16,17], and these may impact on cognitive functioning [18,19]. Obsessive-compulsive personality disorder (OCPD) is a common psychiatric disorder [20,21], affecting around 8 % of patients with cardiovascular diseases [22]. It is more common in older adults [23], yet it is associated with CAD even after adjusting for age [24]. OCPD is described as a chronic dysfunctional pattern of rigid perfectionism and a need for control [25], and is characterised by eight distinct traits: perfectionism, a preoccupation with details, workaholism, over-conscientiousness, hoarding, miserliness, rigidity, and an excessive need for control [26]. Although OCPD is listed as a form of mental disorder in the major classificatory systems, for example, the DSM-5 [26] – largely because of its deleterious effects on interpersonal relationships – individual traits produce context-specific benefits. For example, being meticulous and rule-bound may be helpful in certain occupations where following protocols precisely or a focus on detail is valued.

OCPD has a distinct cognitive profile marked by inflexible thinking [27–29], and mental fatigue [30,31]. Cognitive flexibility refers to the ability to flexibly modify behaviour according to the demands of a changing environment [32]. Mental fatigue has been described as a subjective feeling of tiredness and a lack of motivation [33], and can be marked by problems in cognitive functioning [34]. In a psychotherapeutic context, a lack of cognitive flexibility is thought to impact treatment adherence [35], because some individuals find it difficult to adapt to new situations and environments. Poor cognitive functioning is connected to difficulties in adhering to treatment plans, higher risk of rehospitalisation in individuals with ischemic heart failure [36], with deficits in executive functioning (as measured by Cambridge Automated Neuropsychological Test Battery [CANTAB] Stockings of Cambridge Task [SOC]) predicting non-adherence to medication management in individuals with breast cancer [37]. Cognitive inflexibility and deficits in executive functioning are likely to be important in the treatment and rehabilitation of individuals with CAD since it can put individuals with CAD at risk of poor disease management and functional dependence [5]. Difficulties in treatment adherence, poor disease management, and higher levels of functional dependence would be expected to negatively affect the quality of life and health of individuals with CAD, making them more prone to recurrent cardiovascular events [38].

In individuals with obsessive-compulsive disorder, the diagnosis of obsessive-compulsive disorder was associated with worse acute coronary syndrome prognosis [39]. However, the impact of OCPD on CAD and especially cognition in CAD has yet to be studied. We aimed to investigate the impact of OCPD on executive function in individuals with CAD undergoing rehabilitation, using cognitive tests relevant to cognitive inflexibility and executive planning.

2. Methods

2.1. Study participants

Participants were adult patients who had been admitted to a cardiac rehabilitation programme within two weeks of treatment for acute coronary syndrome (ACS) – that is unstable angina or myocardial infarction. Participants had to be from 18 to 80 years old, have a confirmed diagnosis of CAD and a recent ACS identified by a cardiologist, to have no history of arrhythmic disorder or to have had cardioverter defibrillator implant, and to be fluent in the Lithuanian language. Participants who were known to have dementia, high anxiety (Generalized Anxiety Scale-7 [GAD-7] $\geq$7; [40]) or depressive symptoms (Patient Health Questionnaire-9 [PHQ-9] $\geq$11; [41]) were excluded from the study since depression and anxiety can have an impact on cognitive functioning [18,19].

2.2. Study procedure and measures

The Kaunas Regional Biomedical Research Ethics Committee approved the study protocol and procedure (reference No. BE-2-9, approval date 2021-03-10). The study was conducted in accordance with the Declaration of Helsinki. Each participant signed an informed consent form before participating in the study. A detailed study protocol can be found elsewhere [42].

The study followed a cross-sectional design. Within three days of admission to the cardiac rehabilitation programme, participants underwent an assessment, including an evaluation of their sociodemographic characteristics (e.g., age, sex, education, medication use, and history of smoking). Anxiety symptoms were evaluated using the GAD-7 [43], and depression symptoms using the PHQ-9 [43].

The New York Heart Association (NYHA) functional classification system was used to classify the degree of functional disability based on symptoms of fatigue, palpitation or dyspnea and activity limitations [44]. NYHA Class I refers to no limitation, Class II – slight limitation, Class III – marked limitation in participant's physical activity, Class IV – being unable to carry out any physical activity without discomfort.

Patients also completed the Compulsive Personality Assessment Scale (CPAS; [45]) as a screener for an OCPD diagnosis. Although originally created as an observer-rated scale, the CPAS has been used and validated as a self-report scale [46,47]. The CPAS has eight items, each of which is based on one of the eight DSM-5 diagnostic criteria: preoccupation with details, perfectionism, workaholism, over-conscientiousness, hoarding, a need for control, miserliness, and rigidity. Each item is scored on a scale of zero to four, with the maximum total score equaling 32. Consistent with the DSM-5, a diagnosis of OCPD was defined as a score of three (severe) or four (very severe) on at least four of the CPAS items.

Following the clinical assessment, participants were tested on the following neuropsychological tasks:

2.2.1. Intradimensional-Extradimensional (IED) Set Shifting task [48]

The IED is derived from the Cambridge Neuropsychological Test Automated Battery (CANTAB) [48]. The task assesses rule acquisition and reversal ability, including flexible adaptation of performance to suit the situation.

Participants are asked to make choices between paired stimuli by using feedback provided by the computer. They must learn a rule to find the correct answer each time. The IED consists of nine stages of increasing difficulty, each testing a slightly different aspect of attentional flexibility. After making six successful choices at a particular stage, the participant proceeds to the next one. If the criterion of six correct choices is not reached within 50 trials, the test is discontinued. At the first simple discrimination stage, the participant has to choose one of two stimuli involving the same visual dimension (e.g., one of two differently configured lines). At the following stage (which involves a simple reversal exercise), the previously correct stimulus becomes incorrect and the participant has to adjust their response. At the third stage (which involves a compound discrimination exercise), distracting elements (e.g., shapes) are introduced adjacent to the correct stimuli (e.g., lines), that the participant has to learn to ignore. In the fourth stage, another form of compound discrimination is tested using distracting elements superimposed on the correct stimuli. At the fifth stage (which involves compound reversal), the previously correct stimulus becomes incorrect and vice versa and the participant has to reverse their response. At the sixth stage (the intra-dimensional shift), the participant has to learn to choose the correct dimension from a pair of compound stimuli (e.g. lines and shapes), when the configuration of the correct dimension changes within the same dimension, they have to learn to choose the newly correct configuration. At the seventh stage (the intra-dimensional shift reversal), the participant has to learn that the previously incorrect configuration within the same dimension has become the correct choice and reverse their response. At the eighth (and most difficult) stage (the extra-dimensional shift), the correct choice involves a change in dimension (e.g., from a particular line to a particular shape), the participant has to learn that the correct dimension has shifted and respond accordingly. The ninth stage (the extra-dimensional shift reversal), requires the participant to shift their response to the previously incorrect stimulus [49].

2.2.2. Stockings of Cambridge (SOC) task [48]

The SOC is a computerised version of the Tower of London task, which also derives from the CANTAB [48]. It assesses executive functioning and higher-level cognition, for instance the ability to plan ahead. A set of coloured balls are shown at the top of the computer screen, and another set of balls in a different configuration are shown at the bottom of the screen. The participant is required to work out the minimum amount of moves necessary for the bottom configuration to match the top. The task is repeated with varying levels of difficulty, from a SOC initial thinking time at two moves to a SOC initial thinking time to solve a five-move problem. Performance on the task is measured by the initial thinking time, which assesses the time required to make an initial move on the problem.

2.3. Statistical analyses

Statistical analysis was performed using IBM SPSS Statistics for Windows (version 29.0.0.0; SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to explore the samples' sociodemographic, clinical, and neuropsychological characteristics. Categorical analysis within groups was completed using χ^2 or Mann-Whitney *U* tests. Associations between neuropsychological tests and OCPD traits in the full sample were completed using Spearman's correlational analysis. Finally, multivariable linear regressions controlled by gender and age were completed with the variables that reached statistical significance from the Spearman's correlational analysis.

3. Results

A total of 78 individuals were included in the study (11.5 % female) with a median age of 59.1 (53.0–66.0) years. Table 1 presents a detailed description of the participants.

Ten (12.8 %) individuals fulfilled the operational criteria for DSM-5 OCPD, defined by using the clinician-administered CPAS [45]. Participants with OCPD were compared with those without OCPD in terms of sociodemographic characteristics. The groups did not differ from one another regarding age, gender, education, NYHA functional classes, medication use, history of smoking, severity of depression or anxiety (all *p*-values >.05; Table 1). However, the group of individuals with OCPD were all male, were proportionately more numerically university educated, were numerically more depressed according to the PHQ-9, and smoked less than the group without OCPD.

We then compared the neuropsychological test scores between categorical groups (plus or minus OCPD) using the Mann–Whitney *U* test (Table 2). In the IED set shifting task, individuals with OCPD made more IED intra-dimensional shift reversal errors than those without OCPD (2.0 [2.0–4.0] vs. 1.0 [1.0–2.0], $p = .004$). No significant between-group differences emerged on the SOC task.

We also analysed correlations between neuropsychological test scores and the presence of individual OCPD traits in the full sample (Table 3). The length of initial thinking time on the SOC at five moves was positively associated with the presence of hoarding trait (ρ = 0.242, $p = .033$), and the length of initial thinking time on the SOC at two moves was positively associated with the presence of need for control trait (ρ = 0.259, $p = .022$), and rigidity trait (ρ = 0.239, $p = .035$), that is participants with higher scores on the respective CPAS items spent more time finding solutions to the executive function tasks that required planning. By contrast, IED compound discrimination adjacent stage was negatively associated with a preoccupation with details (ρ = −0.251, $p = .026$); that is participants with higher scores on the CPAS item "Preoccupation with details" made fewer mistakes on the task.

Table 1
Baseline characteristics and cross-sectional clinical measurements for study participants, comparing the groups with and without obsessive compulsive personality disorder (OCPD)*.

	Total (*N* = 78)	Group without OCPD (*N* = 68)	Group with OCPD* (*N* = 10)	p -value**
Age, median (IQR)	59.1 (53.0–66.0)	59.6 (53.3–66.0)	55.2 (49.0–63.0)	0.152
Gender, n (%)				0.564
Men	69 (88.5)	59 (86.8)	10 (100.0)	
Women	9 (11.5)	9 (13.2)	–	
Highest level of education, n (%)				0.082
Tertiary education	46 (59.0)	43 (63.2)	3 (30.0)	
College/ university degree	32 (41.0)	25 (36.8)	7 (70.0)	
NYHA classes, n (%)				0.445
I	43 (55.1)	39 (57.4)	4 (40.0)	
II	33 (42.3)	27 (39.7)	6 (60.0)	
III	2 (2.6)	2 (2.9)	0 (0)	
Medications, n (%)				
Beta blockers	73 (93.6)	65 (95.6)	8 (80.0)	0.120
Statins	75 (96.2)	66 (97.1)	9 (90.0)	0.341
Nitrates	2 (2.6)	2 (2.9)	0 (0.0)	0.583
Benzodiazepines	1 (1.3)	1.0 (1.5)	0 (0.0)	0.700
PHQ-9, median (IQR)	2.0 (1.0–4.0)	2.0 (1.0–4.0)	4.0 (0.0–5.3)	0.189
GAD-7, median (IQR)	0.0 (0.0–3.5)	0.0 (0.0–3.0)	0.0 (0.0–4.3)	0.465
History of smoking, n (%)	25 (32.1)	23 (33.8)	2 (20.0)	0.487

Note: * defined operationally using the Compulsive Personality Assessment Scale (CPAS). ** p-value for age, PHQ-9, and GAD-7 was assessed using the Mann–Whitney U test; p -value for gender, education, and history of smoking was assessed using the χ2 test;

Last, multivariable linear regression was completed with the significant variables, controlled by gender and age. We found that out of all the correlations, only preoccupation with details was not associated with IED compound discrimination adjacent stage after controlling for gender and age (β = −0.188, $p = .104$), while trait hoarding was still associated with initial thinking time on the SOC at five moves (β = 0.243, $p = .036$), traits need for control (β = 0.341, $p = .005$) and rigidity (β = 0.259, $p = .038$) were associated with initial thinking time on the SOC at two moves after controlling for gender and age.

OCPD: obsessive-compulsive personality disorder; IQR: interquartile range; NYHA – New York Heart Association; PHQ-9: Patient Health Questionnaire-9; and GAD-7: Generalized Anxiety Disorder-7.

OCPD: obsessive-compulsive personality disorder; IED: intradimensional-extradimensional set shifting task; SOC: Stockings of Cambridge, and IQR: interquartile range.

4. Discussion

Our findings indicate that individuals with CAD and comorbid OCPD traits have specific difficulties in neuropsychological performance that are not present in individuals with CAD without comorbid OCPD traits: namely, individuals with comorbid OCPD traits show greater cognitive inflexibility than those without comorbid OCPD traits.

Our study found that 12.8 % of participants show signs of OCPD. Although the reported percentage of people with significant OCPD traits in the general population varies between 5 and 8 % [23], the percentage in clinical samples is higher and can reach up to 16.2 % [50]. The higher percentage of individuals with significant symptoms of OCPD could also be due to the self-report on the CPAS scale. However, it is worth noting

Table 2
Neuropsychological test scores for study participants, comparing the groups with and without obsessive-compulsive personality disorder (OCPD)*.

	Total (N = 78)	Group without OCPD (N = 68)	Group with OCPD (N = 10)	p -value**
Intradimensional-extradimensional set shifting task, median (IQR)				
IED simple discrimination, number of errors	1.0 (0.0–1.0)	1.0 (0.3–1.0)	1.0 (0.0–1.3)	0.790
IED simple reversal, number of errors	1.0 (1.0–2.0)	1.0 (1.0–2.0)	1.0 (1.0–2.5)	0.403
IED compound discrimination adjacent, number of errors	1.0 (0.0–3.0)	1.0 (0.0–2.8)	1.0 (0.0–3.3)	0.856
IED compound discrimination superimposed, number of errors	0.0 (0.0–1.0)	0.0 (0.0–1.0)	0.0 (0.0–1.3)	0.782
IED compound reversal, number of errors	1.0 (1.0–1.0)	1.0 (1.0–1.0)	1.0 (1.0–1.5)	0.946
IED intra-dimensional shift, number of errors	1.0 (0.0–3.0)	1.0 (0.0–3.0)	1.5 (1.0–8.5)	0.220
IED intra-dimensional shift reversal, number of errors	**1.0 (1.0–2.0)**	**1.0 (1.0–2.0)**	**2.0 (2.0–4.0)**	**0.004**
IED extradimensional shift, number of errors	10.0 (4.0–23.0)	10.0 (4.0–23.0)	14.0 (3.8–29.5)	0.382
IED extradimensional shift reversal, number of errors	1.0 (1.0–3.0)	1.0 (1.0–3.25)	3.0 (1.0–14.0)	0.356
IED total trials adjusted	107.5 (77.5–152.3)	105.0 (76.0–149.0)	138.5 (97.0–182.0)	0.120
Stockings of Cambridge task, median (IQR)				
SOC initial thinking time at two moves, Msec	2622 (1556–4204)	2461 (1502–3950)	3549.8 (1594–5434)	0.403
SOC initial thinking time at three moves, Msec	5607 (3447–9877)	5215 (3442–9780)	6087 (3410–10,634)	0.754
SOC initial thinking time at four moves, Msec	6299 (5508–10,888)	6240 (3378–10,276)	7461 (3836–14,271)	0.394
SOC initial thinking time at five moves, Msec	9204 (5508–12,874)	9596 (5819–13,035)	7197 (3373–13,562)	0.331

Note: * defined operationally using the Compulsive Personality Assessment Scale (CPAS). ** p -value assessed using the Mann–Whitney U test;

Table 3
Spearman's correlations between obsessive-compulsive personality traits and neuropsychological test scores in the full sample.

		Preoccupation with details	Perfectionism	Workaholism	Over-conscientiousness	Hoarding	Need for control	Miserliness	Rigidity	Total CPAS score
IED simple discrimination, number of errors	ρ	0.033	0.058	−0.138	0.019	−0.134	−0.133	−0.106	−0.075	−0.150
	p	0.772	0.614	0.230	0.871	0.241	0.246	0.357	0.513	0.191
IED simple reversal, number of errors, number of errors	ρ	0.142	−0.083	0.073	0.079	0.031	−0.025	0.014	−0.177	0.016
	p	0.214	0.470	0.525	0.493	0.788	0.830	0.902	0.120	0.890
IED compound discrimination adjacent, number of errors	ρ	**−0.251**	−0.045	0.027	0.138	0.166	−0.199	0.116	−0.022	−0.008
	p	**0.026**	0.698	0.814	0.228	0.146	0.081	0.310	0.848	0.941
IED compound discrimination superimposed, number of errors	ρ	−0.157	0.031	−0.012	−0.001	0.013	0.047	0.034	0.059	0.007
	p	0.173	0.786	0.920	0.993	0.910	0.683	0.771	0.608	0.952
IED compound reversal, number of errors	ρ	−0.129	0.106	0.088	−0.111	0.008	−0.039	−0.114	−0.064	−0.050
	p	0.266	0.364	0.451	0.339	0.942	0.738	0.326	0.581	0.670
IED intra-dimensional shift, number of errors	ρ	0.114	0.003	0.041	−0.090	−0.029	−0.104	0.034	−0.049	−0.034
	p	0.326	0.980	0.723	0.440	0.807	0.370	0.770	0.677	0.769
IED intra-dimensional shift reversal, number of errors	ρ	0.162	0.059	0.123	0.074	−0.071	0.093	0.142	0.072	0.150
	p	0.167	0.615	0.298	0.532	0.549	0.432	0.227	0.540	0.201
IED extradimensional shift, number of errors	ρ	0.211	0.133	−0.178	0.131	−0.083	−0.021	−0.046	0.129	−0.001
	p	0.077	0.270	0.137	0.278	0.490	0.859	0.702	0.284	0.993
IED extradimensional shift reversal, number of errors	ρ	0.102	0.256	−0.181	0.118	0.177	−0.013	0.016	−0.022	0.023
	p	0.477	0.070	0.205	0.408	0.215	0.929	0.911	0.880	0.872
IED total trials adjusted, number of errors	ρ	0.181	−0.010	−0.132	0.208	−0.104	−0.032	0.019	0.055	0.001
	p	0.114	0.932	0.249	0.068	0.363	0.782	0.869	0.630	0.990
SOC initial thinking time at two moves, Msec	ρ	0.002	0.090	0.043	−0.043	0.058	**0.259**	0.024	**0.239**	0.162
	p	0.989	0.436	0.706	0.711	0.616	**0.022**	0.833	**0.035**	0.157
SOC initial thinking time at three moves, Msec	ρ	−0.041	0.052	−0.058	−0.148	0.069	0.043	−0.108	0.126	−0.018
	p	0.720	0.651	0.611	0.196	0.547	0.711	0.347	0.272	0.877
SOC initial thinking time at four moves, Msec	ρ	0.136	0.054	0.042	−0.041	0.118	0.110	0.015	0.198	0.130
	p	0.235	0.641	0.715	0.722	0.302	0.339	0.895	0.082	0.255
SOC initial thinking time at five moves, Msec	ρ	0.069	0.168	−0.015	−0.050	**0.242**	0.033	−0.098	0.156	0.092
	p	0.549	0.142	0.895	0.661	**0.033**	0.771	0.395	0.173	0.422

Note: CPAS: Compulsive Personality Assessment Scale; IED: intradimensional-extradimensional set shifting task; and SOC: Stockings of Cambridge.

that only a small number of individuals with a presumed diagnosis of OCPD (n = 10) emerged in our study. The results should, therefore, be treated with caution, as they may be subject to Type 1 error (i.e., chance findings; see the section on limitations). As the statistical power was low, it was expected that statistically significant findings on the between-group analyses would be difficult to detect. However, though the groups did not differ from each other statistically on sociodemographic characteristics, we observed numerical differences between the groups, with individuals with comorbid OCPD more likely to be male, have a college or university degree, and be more depressed. It may be that certain demographic characteristics are more likely to reflect individuals with CAD and comorbid OCPD. We must stress that despite excluding individuals with higher depression scores (PHQ-9 ≥ 11), the presence of a slightly elevated depression score, albeit not statistically significant, may have influenced the poorer cognitive outcomes observed in the OCPD group.

Analysing the differences between set-shifting ability on the IED task, we found that individuals with CAD and comorbid OCPD made significantly more IED intra-dimensional shift reversal errors (Stage 7), reflecting a difficulty inhibiting previously learned responses (Table 2).

There were additional non-significant numerical changes in other aspects of flexibility in the OCPD group, for example more errors on the two extradimensional shift items (IED extradimensional shift [Stage 8] and IED extradimensional shift reversal [Stage 9]), as well as an increase in the total IED trials adjusted score, thus the number of trials needed to achieve completion of all attempted stages with an adjustment for any stages was not reached, and lower numbers indicated better results. The size of the between-group differences suggests that a lack of statistical significance may reflect a Type 2 error.

Our findings align with previous studies, where inflexible responses to the IED have been associated with OCPD and other obsessive-compulsive spectrum disorders, though the precise staging of the deficits may differ. Thus, the deficits in extra-dimensional shift (Stage 8) were seen in nonclinical cases of OCPD [27]. Similar findings in impaired set-shifting as measured with the Trail-Making B task were also noted by Aycicegi, Dinn [51] in individuals with OCPD and OCPD with schizotypal features compared with a control group. A meta-analytic review by Shin, Lee [52] demonstrated significant deficits in intra-dimensional shifting in individuals with obsessive-compulsive disorder, a distinct condition that shares some similarities with OCPD. Taken together, our findings indicate that CAD patients with OCPD are likely to be more inflexible than those without this comorbidity; though future studies with larger sample sizes would be needed to confirm such a conclusion.

Attentional set-shifting reflects the ability to adapt behaviour flexibly following feedback [53]. Deficits in such ability are an essential factor in cognitive rigidity and repetitive behaviour [54]. Individuals with OCPD tend to be more rigid, fixed in their responses and way of thinking, and have greater difficulty in changing their behaviour [55]. Faced with situations, where they need to adapt and change (as in the IED task), they are more likely to not change their behaviour and continue to respond in old ways, even though it is no longer adaptive. This may be especially important in rehabilitation process, where the main goal is to learn about health-enhancing behaviours and figure out how to implement these in everyday life, letting go of old habits that are likely to be harmful. Individuals with comorbid OCPD who participate in the rehabilitation programmes may be expected to find it more problematic to disengage from old behaviours and more likely to reject new models of behaviour, notwithstanding their benefits.

Although our results were not statistically significant, numerically the OCPD group scored poorer on several items of the SOC (i.e., SOC initial thinking time on two moves, SOC initial thinking time on three moves, SOC initial thinking time on four moves, and SOC initial thinking time on five moves), again possibly reflecting a Type 2 error. However, we hypothesize that individuals with OCPD require more time and are in general slower to solve tasks that require executive functioning (e.g., planning), compared with individuals without OCPD. These findings are consistent with the previous literature [27]. The SOC task showed that individuals with OCPD took longer than the controls for initial think time, and this was significant at three and four moves. They had problems when planning ahead, which suggests that they think for longer than average before attempting to complete a complex task, slowing them down and reducing task efficiency. Further studies involving larger numbers of affected individuals are needed to confirm these findings.

We found additional significant associations between specific OCPD traits and neuropsychological differences amongst the participants as a whole. First, hoarding severity was associated with increased initial thinking time on the SOC at five moves (the most difficult stage), while rigidity and need for control were each associated with increased initial thinking time on the SOC at two moves (a simpler level) even after controlling for gender and age, reflecting slower executive planning. Individuals with these specific traits needed more time before making the first decision in the SOC task. Previous studies have shown that individuals with obsessive-compulsive disorder and hoarding show difficulties in decision making [56], while rigidity is in itself associated with executive dysfunction [57]. According to the DSM-5, slowness in task completion in OCPD may be linked to the need to complete the task perfectly. Slower executive planning means more cognitive resources are needed for decision making. Individuals with OCPD are more prone to mental fatigue [30], which may also be connected to slower planning and difficulty in making decisions. Therefore, individuals with these specific OCPD traits may experience increased difficulties in engaging successfully in the rehabilitation process.

We also noted that preoccupation with details was associated with fewer errors on the compound discrimination (adjacent) stage of the IED (but not the compound discrimination [superimposed] stage). However, the correlation was not significant after controlling for gender and age. In the corresponding IED stage, individuals have to ignore new information and follow the old rule. Fewer errors meant that individuals with OCPD were able to complete the task quicker, showing some hidden advantages a preoccupation with details may offer individuals with OCPD. However, significant aspect must be considered – individuals with OCPD also tend to ignore new information and stick with the old rule, a solution that is exactly needed for this particular stage of the task. A correlational analysis was performed to test the dimensionality of OCPD traits across different aspects of cognitive functioning, but the scores may differ significantly if the analysis were to be performed on the group of individuals with OCPD alone. In short, focusing on details may help in certain situations where detailed information has to be processed and positively impact aspects of rehabilitation where this is prioritised. However, an individual might experience greater difficulty when adapting to new situations if they have an OCPD diagnosis. Another important aspect is the effect that gender and age can have on the relationship. Future studies should look into gender and age differences in specific cognitive inflexibility tasks.

Finally, the total CPAS score, a composite measure of the magnitude of the full range of OCPD traits, did not correlate with performance on any of the neuropsychological tasks. This suggests that specific OCPD traits (e.g., a preoccupation with details, the need for control, and rigidity) independently affect aspects of cognitive performance (e.g., cognitive inflexibility or executive planning), and are more relevant as moderators of cognitive function than a full OCPD diagnosis. Future research in this area could use a continuous or dimensional measure of OCPD severity and look into how the OCPD severity score affects the performance on the executive functioning tasks.

5. Limitations

Because of the small sample size of the OCPD group ($n = 10$), any indication of increased inflexibility and planning deficits amongst those with OCPD must be treated preliminarily and indicatively. Nevertheless, given that both the categorical and dimensional analyses provided complementary evidence pointing to the possibility that executive impairment in these domains is associated with the presence of OCPD comorbidity, our findings suggest that these cognitive problems pertain but that large-scale research into cognitive flexibility in the CAD community is required.

Personality disorders are likely to co-occur [58], and significant correlations can be found between cardiovascular diseases and various personality disorders [59]. Given such information a possible limitation of the study is the exclusion of other personality disorder prevalent in CAD population.

Some limitations of our study are connected to the chosen study design: we used a convenience sample, making it harder to generalise from the results, as well as our cross-sectional study design prevented us from making inferences about causality. No cognitive tests were employed to rule out mild cognitive impairment. Future research should employ specific measures to control for the possible effect of mild cognitive impairment. Another possible limitation is concerned with the self-report of the CPAS scale and the validity of the OCPD diagnosis. Future research should employ further validity measures in order to confirm OCPD diagnosis. Last, due to exploratory nature of the study, corrections for multiple comparisons were not performed [60,61].

6. Conclusions

Notwithstanding the above limitations, the results of our study suggest that individuals with CAD and comorbid OCPD and its traits show greater cognitive inflexibility than those without OCPD. Several OCPD traits were associated with slower planning even after controlling for age and gender. In the case of individuals with CAD who already have cognitive impairments directly related to their cardiac disease [4], impairments in neuropsychological performance may have significant implications for rehabilitation. Future researchers might carry out studies involving longitudinal designs, measuring rehabilitation outcomes and the role of mental fatigue.

CRediT authorship contribution statement

Agne Stanyte: Writing – review & editing, Writing – original draft, Conceptualization. **Naomi A. Fineberg:** Writing – review & editing. **Julija Gecaite-Stonciene:** Writing – review & editing. **Aurelija Podlipskyte:** Writing – review & editing, Methodology, Formal analysis, Data curation. **Julius Neverauskas:** Writing – review & editing, Methodology. **Alicja Juskiene:** Writing – review & editing, Methodology. **Vesta Steibliene:** Writing – review & editing, Methodology, Conceptualization. **Nijole Kazukauskiene:** Writing – review & editing, Project administration, Funding acquisition. **Julius Burkauskas:** Writing – review & editing, Methodology, Conceptualization.

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2) Julija Gecaite-Stonciene works as a consultant at FACITtrans.

3) In the past two years Julius Burkauskas has been serving as a consultant at IQVIA.

4) Other authors have no conflicts of interest to declare.

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