

The Psychological Impact of Test Results Following Diagnostic Coronary CT Angiography

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Objective: Coronary computed tomography (CT) angiography is an advanced cardiac imaging test commonly used for diagnosing early signs of ischemic heart disease. Despite its importance in cardiology, little is known about its psychological effect on patients. The present study sought to examine these effects in relation to illness perceptions, cardiac health behavior intentions, and subsequent health behaviors. **Methods:** Forty-five nonacute cardiac patients who were referred for diagnostic coronary CT angiography completed questionnaires prior to testing and following the receipt of test results, at which point illness perceptions and intentions to take cardiac medication, as well as diet and exercise intentions were measured. Exercise and dietary behaviors were measured at follow-up 6 weeks later. Changes on these variables were then compared between patients diagnosed with normal arteries and patients diagnosed with diseased arteries. **Results:** Compared to positive-testing patients, patients with normal test results reported significant changes toward more positive illness perceptions following testing, with improvements in emotional effect of illness, illness concern, consequences, and personal control of illness. The illness perception of treatment control was seen as more important among positive-testing patients, whereas both groups reported increases in illness coherence. Health behavior intentions (cardiac medication intentions and exercise intentions) increased for positive-testing patients only, as did physical activity at follow-up. **Conclusions:** Diagnosis-dependent psychological effects can be detected following coronary CT angiography. These effects have important implications for patient health and health care in diagnostic contexts, and the results from this study can be used to guide further research in this area.

Keywords: coronary CT angiography, illness perceptions, health behavior, diagnostic testing

Coronary computed tomography (CT) angiography is a commonly performed cardiac diagnostic test, with an estimated 2.3 million procedures performed annually in the United States (National Council on Radiation Protection & Measurements, 2009). The test offers a clear visual representation of the human heart and is ideal for providing accurate diagnosis of early ischemic heart disease (Amsterdam & Caputo, 2008), particularly among patients who have multiple cardiac risk factors present (Moser, O'Keefe, Bateman, & McGhie, 2003). In this context, imaging is utilized to determine the build-up of coronary calcium, which is used as a marker for the presence of coronary atherosclerosis among at-risk patients (Agatston et al., 1990).

Despite its utility and value as a cardiac testing procedure, very little research has been conducted on the psychological impact of

coronary CT angiography—particularly its effect on patients' illness perceptions and subsequent health behaviors. Research on the way in which individuals perceive their symptoms and health has shown that cognitive representations of illness have profound implications for adaptive outcomes and health (Hagger & Orbell, 2003; Petrie, & Weinman, 2006). According to Leventhal, Nerenz, and Steele's (1984) self-regulation model, an individual's cognitive representation of an illness is organized around specific attributes, or illness perceptions (identity, timeline, cause, consequences, and control beliefs), which in turn determine coping. The self-regulation model has been used to examine a variety of health issues, such as coping with chronic illness (Petrie, Jago, & Devcich, 2007), behavior change following illness (Broadbent, Ellis, Thomas, Gamble, & Petrie, 2009; Petrie, Cameron, Ellis, Buick, & Weinman, 2002), and treatment adherence (Horne & Weinman, 1999).

Illness perceptions appear to be relatively stable over time in clinical populations (Foster et al., 2008; Rutter & Rutter, 2007). However, a study conducted within a coronary angiography setting with nonacute cardiac patients demonstrated that illness perceptions can change immediately in response to diagnosis (Devcich, Ellis, Gamble, & Petrie, 2008). In the study, wherein illness perceptions were measured prior to and immediately following testing, patients who received normal test results reported an immediate, significant reduction in illness identity, illness conse-

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quences and emotional effect, whereas patients who were diagnosed with ischemic heart disease (IHD) reported no change on the same illness perception variables. This diagnosis-dependent pattern suggests that patients within the context of medical testing prepare themselves cognitively for an unfavorable diagnosis and outcome, perhaps to assist coping. The relationship between patients' illness models and the diagnostic procedure can be better understood through Leventhal et al.'s (1984) model, in which individuals are seen as active processors of illness information and where patients' illness appraisals play an important role in informing subsequent coping strategies as well as ongoing health behavior (Petrie & Weinman, 2006) and health outcomes (Hagger & Orbell, 2003).

Another way to determine the psychological effect of diagnostic testing is to consider it in the context of health behavior. Some research suggests that cardiac diagnostic procedures may have an effect on patients' behavioral intentions and subsequent health behaviors (Bruce, DeRouen, & Hossack, 1980; Wong et al., 1996), indicating that cardiac testing procedures could play a pivotal role in encouraging behavior change. Other research, however, is less clear on these effects. For example, Robertson and colleagues (1992) found that patients who were given health behavior advice and informed of their cholesterol results subsequent to testing were no more likely to quit smoking or change their diet than advice-receiving patients who were not told their results.

The use of medical images may be a key factor to consider in enhancing the motivational effects of diagnostic testing. Research has demonstrated that using test images can increase medication adherence (Kalia et al., 2006), and the incorporation of imagery has been shown to improve patients' illness knowledge and understanding (Karamanidou, Weinman, & Horne, 2008). It is likely that scan images, such as those produced by CT technology, may facilitate patients' interpretation of test results by offering clearer representations of the disease process—which is more difficult to illustrate using electrocardiogram tracings or cholesterol level figures, for example, where the meaning of results is likely to be less tangible to the untrained eye. The challenging task of encouraging changes in patients' health behavior could therefore be enhanced through the use of advanced, image-centered testing procedures such as coronary CT angiography. At this point, however, research in this area is both limited and equivocal (Hollands, Hankins, & Marteau, 2010).

The present study therefore aimed to investigate the psychological impact that coronary CT angiography has on patients' illness perceptions, health behavior intentions, and health behaviors. We predicted that patients with negative test results (i.e., no significant disease present) would show changes toward more positive illness perceptions following testing. We also predicted that patients with positive test results (i.e., scans showing calcium plaques) would demonstrate increases in behavioral intentions and cardiac-related health behaviors following testing.

Method

Participants

The study comprised 45 nonacute adult patients who were recruited from a private cardiac clinic in Auckland, New Zealand. Participants were referred to the clinic for a diagnostic coronary

CT angiogram to assess the presence and extent of coronary artery calcification. Only patients undergoing coronary CT angiography for the first time were included in the study, and non-English-speaking patients were excluded from taking part.

Sixty-nine consecutive patients who met the study's inclusion criteria were approached at the clinic by a researcher who solicited their participation in the study, at which point 12 declined to take part. Of the remaining 57 participants who then enrolled in the study at baseline, one withdrew from the study following the angiogram and eight were excluded due to incomplete questionnaires. Three further participants were unable to be contacted at follow-up. The flow of participants through the study is illustrated in Figure 1.

Participants' ages ranged from 35 to 80 years (mean [M] = 55.62, standard deviation [SD] = 8.25). The sample consisted of a higher ratio of males to females (69% male), with most participants identifying themselves as New Zealand European ethnicity (91%). Most participants were in full-time employment (69%) and had received a tertiary education (76%). Following coronary CT angiography, 20 patients were diagnosed with normal coronary arteries and 25 received a positive diagnosis with the presence of more than trivial coronary artery calcification and atheromatous plaque.

Procedure

The study received ethical approval from The University of Auckland Human Participants Ethics Committee. After providing written consent to take part in the study, participants filled out a baseline questionnaire before undergoing their coronary CT angiogram. The questionnaire covered demographic and clinical variables, illness perceptions, and current cardiac health behaviors and health behavior intentions. Patients' scan results were then processed by their cardiologist and were relayed back during consultation at the clinic in the week following their angiogram. At this point, after receiving their scan results, participants filled out the second questionnaire, which again measured illness perceptions and cardiac health behavioral intentions. Finally, a follow-up questionnaire, which covered participants' current cardiac health

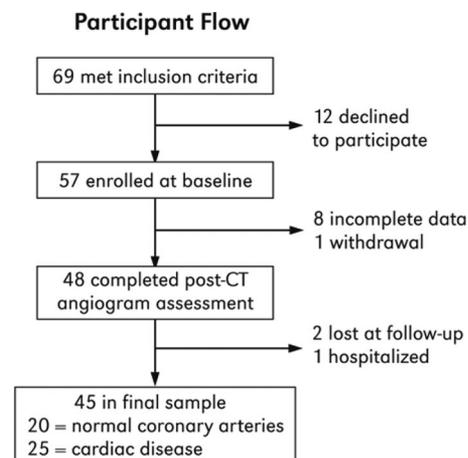


Figure 1. Participant flow through the study.

behaviors, was administered via telephone 6 weeks after patients' diagnostic consultation.

Classification into diagnostic groups was assisted through viewing the artery diagrams of each participant and the corresponding Agatston score—a number given by the cardiologist based on the density and volume of coronary artery calcification. The patient's Agatston score is referenced against tables that compare it with an age and gender matched population sample, yielding a final quartile placement that gives an indication of the patient's relative artery health (Hoff et al., 2001). For the present study, patients were classified as having "normal" arteries if they were placed within the first quartile and had an Agatston score less than 10, indicating healthy arteries or arteries with minimal disease (Hoffmann, Brady, & Muller, 2003; Oschatz, Benesch, Kodras, Hoffmann, & Haas, 2006). Patients placed within the remaining three quartiles or with Agatston scores greater than 10 were deemed to have "diseased" arteries (range = 5–818 Agatston units).

Measures

Baseline demographic and clinical data. Participants were asked to provide demographic information including age, gender, ethnicity, employment status and level of education. Participants were also asked whether they had undergone any previous cardiac testing. Clinical data included lipid levels (e.g., total cholesterol, high-density lipoprotein, low-density lipoprotein, triglycerides) and an assessment of risk factors (i.e., smoking history, family history of ischemic heart disease, clinical hypertension) and whether patients were taking cardiac medication. Anxiety was measured at baseline using the six-item short form of the State-Trait Anxiety Inventory (STAI), a scale that has shown good internal consistency ($\alpha = .82$) comparable to the original STAI (Marteau & Bekker, 1992). To measure self-rated health, participants were asked to rate their current health in comparison to someone in excellent health on a 7-point scale ranging from *terrible* to *excellent* (Johnston, Wright, & Weinman, 1995).

Illness perceptions. The Brief Illness Perception Questionnaire (Brief IPQ; Broadbent, Petrie, Main, & Weinman, 2006) was used to assess the range of patients' illness beliefs at baseline and immediately following diagnostic consultation. The nine-item Brief IPQ measures key dimensions related to how patients cognitively and emotionally represent their illness (identity, coherence, timeline, cause, consequences, personal control of illness, treatment control, concern, and emotional effect of illness). Each item is measured on an 11-point scale (0–10), with higher scores indicating a stronger endorsement of each statement. The brief IPQ has been used in a wide range of patient populations (e.g., Devcich et al., 2008; Giri, Poole, Nightingale, & Robertson, 2009; Lantéri-Minet et al., 2007) and has been shown to have good test-retest reliability and concurrent validity (Broadbent, Petrie, Main, & Weinman, 2006).

Cardiac health behavior intentions. Patients' cardiac health behavior intentions were measured at baseline and immediately following diagnostic consultation. Intentions to engage in regular exercise, to eat a heart-healthy diet and to take cardiac medication were measured respectively on three 7-point scales adapted from Norman, Conner and Bell's (2000) study on exercise behavior. For example, exercise intention was measured using the item "I intend to take regular exercise during the next 6 months," and the item "I

intend to take regular cardiac medication during the next 6 months" assessed medication intentions. Patients were required to respond on a linear scale that ranged from -3 (not at all) to $+3$ (definitely). Norman et al. (2000) reported very high internal consistency ($\alpha = .95$) for the original behavior intention scale.

Cardiac health behavior. The cardiac health behaviors of patients were assessed at baseline and at follow-up 6 weeks after diagnostic consultation. Participants were asked to indicate on a 12-point scale the frequency with which they engaged in exercise, with exercise defined as activities (e.g., jogging, walking, aerobics) that did not form part of everyday life, such as walking to the bus stop (Norman & Smith, 1995). The scale ranged from 0 (*never*) to 11 (*every day*). In addition, two 7-point items ("How strictly do you follow a heart-healthy diet?" and "How often do you follow a heart-healthy diet?"), with a response range from -3 to $+3$, were used to measure dietary behavior. The two items were combined to yield a score for healthy diet behavior ($\alpha = .88$).

Results

Preliminary Analyses

Statistical analyses—including independent-samples *t* tests, chi-square tests and Fisher's exact tests, where appropriate—were carried out to determine whether there were any significant differences between the diagnostic groups at baseline. Results showed no between-groups differences at baseline with regard to demographic variables, cardiac risk factors (e.g., lipids, smoking history, family history of IHD, clinical hypertension), and measures of anxiety and self-rated health. Health behaviors at baseline were also analyzed, again showing no between-groups differences for both exercise frequency and healthy diet behavior. Table 1 displays the various clinical and behavior variables at baseline across both diagnostic groups in the study.

Illness Perceptions

Repeated-measures analysis of variance (ANOVA) tests were conducted to evaluate the effect of coronary CT angiography test results on patients' illness perceptions (see Table 2). Bonferroni-corrected ($p = .05/3$) post hoc independent- and related-samples *t* tests were employed subsequently to test differences between groups and over time, respectively. Significant Group \times Time interactions were found for a number of illness perceptions: illness identity, $F(1, 40) = 5.52, p = .02$; emotional effect, $F(1, 38) = 4.82, p = .03$; illness concern, $F(1, 40) = 12.29, p = .001$; personal control, $F(1, 37) = 8.06, p = .007$; and treatment control, $F(1, 37) = 6.05, p = .019$. Significant time effects were found for consequences, $F(1, 40) = 8.80, p = .005$, as well as illness coherence, $F(1, 38) = 28.03, p < .001$.

Post hoc tests revealed significant decreases in illness perceptions, emotional effect, $t(17) = 2.80, p = .01$; illness concern, $t(18) = 4.11, p = .001$; and illness consequences, $t(18) = 2.68, p = .015$, for patients with normal arteries compared to no changes on these variables for patients with diseased arteries. A significant increase was found for personal control of illness for normal-testing patients, $t(16) = -3.17, p = .006$, but not for patients with scans finding evidence of significant calcium plaques. These results indicate that patients with normal findings reported a shift

Table 1
Clinical and Health Behavior Variables Across Diagnostic Groups at Baseline

Baseline variable	Coronary CT angiography diagnostic group		<i>p</i>
	Normal arteries (<i>n</i> = 20)	Diseased arteries (<i>n</i> = 25)	
Lipids, <i>M</i> (<i>SD</i>)			
Total cholesterol (mmol/L)	5.62 (1.16)	5.27 (0.95)	.27
HDL cholesterol (mmol/L)	1.63 (0.43)	1.45 (0.46)	.21
LDL cholesterol (mmol/L)	3.46 (1.12)	3.14 (0.74)	.26
Triglycerides (mmol/L)	1.18 (0.46)	1.36 (0.59)	.29
On cardiovascular medication	6 (30)	10 (40)	.49
Smoking history	2 (10)	5 (20)	.44
Clinical hypertension	1 (5)	5 (20)	.21
Family history of IHD	10 (50)	17 (68)	.30
Anxiety, <i>M</i> (<i>SD</i>)	11.45 (3.59)	11.96 (3.22)	.62
Self-rated health, <i>M</i> (<i>SD</i>)	5.75 (0.72)	5.63 (0.65)	.55
Heart-healthy diet, <i>M</i> (<i>SD</i>)	9.00 (1.26)	8.76 (2.86)	.73
Exercise, <i>M</i> (<i>SD</i>)	7.90 (2.79)	7.32 (3.12)	.52

Note. Except where indicated, values show number of participants (with percentages in parentheses). HDL = high-density lipoprotein; LDL = low-density lipoprotein; IHD = ischemic heart disease; *M* = mean; *SD* = standard deviation.

toward more positive illness perceptions following diagnosis. For the remaining illness perceptions (treatment control and illness coherence), post hoc tests revealed significant increases in treatment control for positive-testing patients, $t(20) = -2.70, p = .014$, but not for patients with scans indicating no significant disease, and significant increases in illness coherence were demonstrated for both groups, $t(18) = -3.81, p = .001$ and $t(20) = -3.66, p = .002$ for negative- and positive-testing patients, respectively. In other words, only patients with scans showing diseased arteries reported an increase in the belief that their illness could be controlled by treatment (e.g., medication), whereas both groups reported an increase in how well they felt they understood the condition of their heart.

Cardiac Health Behavior Intentions and Behaviors

Repeated-measures ANOVAs were used to assess any changes in patients' cardiac health behavior intentions and subsequent health behaviors in response to coronary CT angiography test

results (see Table 3). Post hoc independent- and related-samples *t* tests with Bonferroni corrections ($p = .05/3$) assessed differences between groups and over time. Significant Group \times Time interactions were found for intention to take cardiovascular medication, $F(1, 40) = 6.24, p = .017$, and intention to exercise, $F(1, 42) = 7.84, p = .008$. Post hoc tests showed significant increases on both intention variables for patients with scans indicating diseased arteries—cardiovascular medication intentions, $t(41) = -3.25, p = .002$; exercise intentions, $t(24) = -2.86, p = .009$ —but not for patients with normal arteries. These results indicate that patients with positive test results (i.e., scans showing the presence of significant disease) showed an increase in intentions to take cardiovascular medication and engage in physical activity; patients with negative findings, however, showed no change. In terms of cardiac health behaviors, both dietary behavior and exercise behavior showed a significant Group \times Time interaction effect— $F(1, 43) = 7.47, p = .009$ and $F(1, 43) = 8.02, p = .007$, respectively. However, post hoc tests revealed that only exercise behavior

Table 2
Illness Perceptions Across Diagnostic Groups Before and After Coronary CT Angiography

Illness perception variable	Normal arteries (<i>n</i> = 20)				Diseased arteries (<i>n</i> = 25)			
	T1	T2	T1-T2	95% CI	T1	T2	T1-T2	95% CI
Illness identity	1.84 (1.71)	1.15 (1.64)	0.69	0.06 to 1.31	1.56 (1.93)	2.13 (2.38)	-0.57	-1.42 to 0.29
Illness emotion	4.00 (2.68)	2.72 (2.61)	1.28*	0.32 to 2.24	2.95 (2.70)	3.09 (3.24)	-0.14	-1.07 to 0.79
Illness concern	6.11 (2.11)	3.42 (2.83)	2.69*	1.31 to 4.06	6.26 (2.67)	6.09 (2.66)	0.17	-0.58 to 0.93
Illness consequences	5.95 (2.34)	3.84 (2.89)	2.11*	0.45 to 3.76	6.35 (2.55)	5.48 (2.71)	0.87	-0.46 to 2.19
Personal control	6.71 (2.28)	8.11 (1.11)	-1.40*	-2.36 to -0.47	7.18 (1.33)	6.50 (2.28)	0.68	-0.46 to 1.82
Treatment control	7.05 (1.83)	6.50 (3.01)	0.55	-0.88 to 2.00	6.81 (2.87)	8.62 (0.97)	-1.81*	-3.21 to -0.41
Illness coherence	5.47 (2.48)	8.32 (1.53)	-2.85*	-4.41 to -1.27	5.95 (3.35)	8.38 (1.99)	-2.43*	-3.81 to -1.04
Illness timeline	5.64 (3.22)	4.35 (4.25)	1.29	-0.74 to 3.33	7.00 (3.15)	7.40 (3.25)	-0.40	-1.81 to 1.01

Note. Values show Brief IPQ means with standard deviations in parentheses. T1 = measurement at baseline; T2 = measurement immediately following diagnostic consultation; CI = confidence interval.
* *p* significant on post hoc tests ($p < .05/3$).

Table 3

Cardiac Health Behavior Intentions and Cardiac Health Behaviors Across Diagnostic Groups Before and After Coronary CT Angiography

Cardiac health behavior intentions	Normal arteries				Diseased arteries			
	T1	T2	T1-T2	95% CI	T1	T2	T1-T2	95% CI
Cardiac medication	3.77 (1.73)	4.44 (2.25)	-0.67	-1.93 to 0.60	3.38 (2.36)	5.92 (0.28)	-2.54*	-3.51 to -1.57
Heart-healthy diet	5.36 (0.60)	5.63 (0.60)	-0.27	-0.58 to 0.52	5.24 (0.88)	5.56 (0.71)	-0.32	-0.61 to -0.4
Exercise	5.63 (0.68)	5.47 (0.70)	0.16	-0.13 to 0.45	5.36 (1.15)	5.80 (0.50)	-0.44*	-0.76 to -0.12
Cardiac health behavior	T1	T3	T1-T3	95% CI	T1	T3	T1-T3	95% CI
Heart-healthy diet	9.00 (1.26)	8.10 (2.17)	0.90	0.14 to 1.66	8.76 (2.86)	9.52 (2.47)	-0.76	-1.71 to 0.19
Exercise	7.90 (2.79)	6.90 (3.40)	1.00	-0.35 to 2.35	7.32 (3.11)	8.28 (2.61)	-0.96*	-1.67 to -0.25

Note. Values show means with standard deviations in parentheses. T1 = measurement at baseline; T2 = measurement immediately following diagnostic consultation; T3 = measurement at follow-up 6 weeks after diagnostic consultation; CI = confidence interval.

* p significant on post hoc tests ($p < .05/3$).

changed significantly, with positive-testing patients showing an increase on this variable, $t(24) = -2.79$, $p = .01$. This result thus shows that only patients with a disease-positive diagnosis following coronary CT angiography reported an increase in physical activity at follow-up.

Discussion

The results from the present study demonstrate a diagnosis-dependent effect on illness perceptions among nonacute cardiac patients undergoing diagnostic coronary CT angiography: emotional effect, illness concern, illness consequences, and personal control all showed a shift toward more benign perceptions among negative-testing patients but remained unchanged for patients with scans showing coronary artery calcification. In other words, negative findings (1) allayed patients' concern about and emotion around their heart condition, (2) reduced the degree to which patients believed that their life would be affected by their heart's condition, and (3) increased a sense of personal control over their cardiac-related health. This illness perception change for negative-testing patients supports earlier findings from a study conducted among patients who underwent conventional coronary angiography (Devcich et al., 2008) and supports the conclusion that patients appear to prepare themselves cognitively for an unfavorable diagnosis prior to testing, perhaps as a preemptive coping strategy toward an unknown threat. The high levels of emotional effect of illness and illness concern prior to testing could also reflect high pretesting state anxiety that is reported in cardiac settings (De Jong-Watt & Arthur, 2004; Gallagher, Trotter, & Donoghue, 2010), but findings from the present study suggest that illness-related concerns are allayed immediately following a benign diagnosis.

Diagnosis-dependent responses were detected for control beliefs among positive-testing patients, who reported increases in the illness perception of treatment control following diagnosis. This shift toward viewing treatment as more helpful may have positive consequences for medication adherence (Horne & Weinman, 1999), which is pertinent given that adherence to cardiovascular medications such as statins can be an issue, partly due to individuals' beliefs around illness and treatment (Mann, Allegrante, Natarajan, Halm, & Charlson, 2007). The results concerning illness coherence—where it was shown to increase for both diagnostic

groups, reflecting an improvement in the degree to which patients felt they understood the condition of their heart—may have implications for patient education in diagnostic settings. It is possible that viewing the scan images bolstered illness coherence levels (Karamanidou et al., 2008), although the present study was unable to isolate other possible contributing factors such as the consultation process and communication skills of the cardiologist.

The demonstrated changes in health behavior intentions also showed diagnosis-related characteristics. Compared to those with normal coronary CT angiogram findings, patients who received test results that demonstrated the presence of coronary artery calcification reported an increase in intentions to take cardiovascular medication and engage in exercise. Further, patients in this group were more likely to report an increase in exercise behavior at follow-up 6 weeks after diagnostic consultation. These findings corroborate other research that has demonstrated the influence that coronary calcium imaging tests can have on health behavior change, including smoking cessation (Bovet, Perret, Cornuz, Quilindo, & Paccaud, 2002; Rodondi et al., 2008) and adherence to cardiovascular medication (Kalia et al., 2006). Although analysis of adherence rates was not possible in this study, the results nonetheless illustrate an important shift in positive-testing patients' intentions to take cardiac medication, a finding that backs up the observed change in treatment control perceptions.

The findings related to exercise intentions and subsequent exercise behavior are encouraging, although they run counter to previous research set within the context of advanced cardiac imaging tests. For example, Lederman, Ballard, Njike, Margolies, and Katz (2007) were unable to find any benefit of coronary CT imaging in relation to physical activity and medication use, and another study failed to demonstrate motivational effects of cardiovascular screening and electron beam tomography on a number of behavioral measures, including physical activity (O'Malley, Feuerstein, & Taylor, 2003). A point of difference that could explain this inconsistency in findings, however, may relate to the population used in the studies: the above studies recruited participants that were not representative of typical clinical populations (e.g., military personnel and postmenopausal participants); the present study, on the other hand, comprised patients who were

referred for diagnostic testing at a cardiac clinic. Given this context, the results point toward the potential role that coronary CT angiography and the testing environment may have in encouraging physical activity (and possibly other health behaviors) among patients undergoing cardiac evaluation.

The study has particular relevance for clinical practice. First, the results show that illness perceptions can change quickly following diagnosis. This means that the diagnostic process may offer a window of opportunity for addressing patients' cognitions around their health and symptoms. As heart-related illness perceptions have been shown to be important for cardiac patients' health outcomes (e.g., Petrie, Weinman, Sharpe, & Buckley, 1996), addressing unhelpful illness beliefs at this stage could therefore be advantageous. Second, the study has implications for addressing cardiac patients' health behavior intentions. For example, physicians are encouraged to advise patients on the advantages of quitting smoking, and a particularly advantageous time to put across a persuasive message is around diagnosis (Graham et al., 2007). The present study also suggests that placing emphasis on other important health-protective behaviors (particularly physical activity, but perhaps also dietary behavior) may also be of value at this stage to help encourage heart-healthy behaviors and counteract risk complacency.

The major strength of the present study is the clinical setting in which it was conducted and the patient sample it comprised—features that contribute greatly to its ecological validity. However, some limitations need to be kept in mind. First, limitations concerning behavior variables include the use of self-reported measures and the short follow-up period. Since healthy patterns of diet and physical activity over the long term are central to the prevention of heart disease (Nusselder, Franco, Peeters, & Mackenbach, 2009), a longer follow-up period, perhaps with more objective measures of health behaviors, would have added to the clinical significance of the study. Also, as mentioned above, it was not possible to isolate the potential contributing factors that may have influenced changes in illness perceptions, health behavior intentions and ensuing health behaviors. Other limitations include the small sample size and the omission of illness perception measurement at follow-up, which may have provided more information about the stability of the observed illness perception changes.

Nonetheless, directions for further research are clear from the findings of the present study. The use of coronary CT angiogram images during consultation may have significance for patient understanding (Karamanidou et al., 2008) and reassurance (Petrie et al., 2007), which could, in turn, shape future behavior patterns. Experimental research could examine the use of scan images in consultation within authentic clinical settings, thus contributing to a limited literature marked by equivocal findings. Moreover, investigation of any negative or anxiety-inducing effects of viewing scan images from tests demonstrating coronary artery calcification, could be of further value to clinical practice.

The finding that negative-testing patients showed decreases in perceived illness consequences following testing as well as no change in health behavior at follow-up suggests that lower cardiac risk perceptions may have influenced later patterns of health behavior (Prentice–Dunn & Rogers, 1986). Prospective research could therefore explore the relationship between these variables within the context of medical testing, particularly focusing on the extent to which perceived and actual risk line up and how this affects health-protective behaviors (Gholizadeh, Davidson, Sala-

monson, & Worrall–Carter, 2010). Lastly, the diagnosis-dependent effects on cardiovascular medication intentions and treatment control perceptions point toward the need for further research on the influence that diagnostic testing may have on medication adherence. As medication and treatment representations have important consequences for adherence (Horne, 1997), research on this topic could indeed prove to be valuable for patient health care.

Coronary CT angiography impacts psychologically on individuals in many significant ways, ranging from the ways in which illness is perceived through to motivations for health behavior and subsequent behaviors. These effects generally appear to be related to the nature of the test results, as witnessed by the diagnosis-dependent changes to a number of illness perception and health behavior variables. These results point to the need for further enquiry into the various aspects and effects of diagnostic testing, particularly with regard to advanced cardiac imaging tests such as coronary CT angiography. Research in this area is of particular value, as the results of diagnostic testing appear to have important implications for health.

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