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Sense of Coherence is associated with LDL-cholesterol in patients with type 1 diabetes – The PROLONG-Steno study

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ABSTRACT

Aim: It is a constant challenge for people with type 1 diabetes to maintain appropriate levels of HbA_{1c}, blood pressure and blood lipids in order to prevent or delay deleterious effects of their illness. This study sought to investigate if Sense of Coherence (SOC) is associated with clinical risk factors in people with type 1 diabetes.

Methods: Questionnaire data, including measure of SOC, was collected from 125 patients with long duration of type 1 diabetes and linked to electronic patient records to obtain clinical measures on HbA1c, blood pressure, and blood lipids. Linear regressions and generalized additive models were applied to explore the associations between SOC and clinical biomarkers.

Results: Mean age of the participants was 60.7 years (standard deviation = 10.0), 44.0% were men. Medium and high SOC were associated with lower levels of LDL-cholesterol ($p = 0.005$). This association was non-linear with medium and high levels of SOC being advantageous whereas low SOC was associated with elevated levels of LDL-cholesterol. Moreover, we observed non-significant tendencies to associations between low SOC and low HDL-cholesterol, and elevated HbA_{1c}.

Conclusions: Findings from this study suggest that high SOC may be protective against elevated LDL-cholesterol among people with type 1 diabetes. Interventions to improve self-management among people with low SOC may prove effective to prevent deterioration of metabolic risk factors.

Introduction

Successful self-management is a cornerstone for people with diabetes in maintaining well-controlled blood glucose levels and preventing elevated blood pressure and dyslipidaemia, which, in the long term increase risk of development of diabetic complications, morbidity and mortality. Despite multifactorial intervention efforts to control these risk factors, there is an unmet need for improving clinical management strategies to prevent diabetes progression and improve professional abilities and quality of life in patients with type 1 diabetes [1].

Sense of Coherence (SOC) is a concept coined by Aaron Antonovsky [2] which constitutes a resource that enables people to cope with life challenges in a health-promoting manner. The concept was originally developed to determine how some people manage to maintain well-being despite chronic or extreme stress exposure. A questionnaire scale to measure SOC, developed by Antonovsky, has been widely used in health research [3]. Higher SOC has been associated with improved self-management in relation to chronic diseases [4], including diabetes [5]. Thus, high SOC is suggested to be protective against development of type 2 diabetes [6,7] and associated with successful lifestyle change in subjects at risk of type 2 diabetes [8]. Among people with diabetes high SOC has been associated with high diabetes-specific self-efficacy [9], prudent food choices and higher physical activity [10], improved glycaemic control measured with HbA1c [11] and decreased risk of complications in men [1]. The SOC concept measures the capacity of an individuals to effectively cope with life events such as chronic disease [12]. Thus, high SOC has been associated with enhanced self-management among people with chronic illness such as; prudent food choices [13], successful lifestyle changes [8,14], and medical adherence [15].Factors that contribute to avoidance of adverse consequences of diabetes.

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SOC may explain why some patients manage to stay free of chronic diabetes complications despite similar disease challenges, while others experience deleterious consequences of their disease. Despite a growing body of research on diabetes management, studies on associations between SOC and diabetes progression are still scarce. Specifically, the association between SOC and clinical biomarkers such as blood pressure and lipid profiles have not yet been studied in patients with type 1 diabetes. Therefore, we aimed to quantify the association between SOC and HbA_{1c} and lipids, respectively in patients with type 1 diabetes and long disease duration.

Material and methods

Study population

The current study is nested within the PROtective genetic and non-genetic factors in diabetic complications and LONGevity (PROLONG) study. Briefly, The PROLONG study (2011–2015) was an observational, multi-Center Scandinavian study of type 1 diabetes patients who despite long diabetes duration of more than 30 years escaped diabetic complications, and patients who developed persistent micro albuminuria or macro albuminuria, proliferative retinopathy or laser treatment, myocardial infarction, stroke or presence of chronic foot ulcer, in the course of 25 years following onset of diabetes. A total of 430 patients attended a clinical examination at one of seven endocrinology/diabetes clinics in Sweden or at the Steno Diabetes Center in Denmark (n = 183), including measurement of anthropometry, biochemistry as well as a questionnaire on family history of diabetes, lifestyle, psychosocial health and social status. The questionnaire used as part of the study visit at the Steno Diabetes Center was modified to include the battery of questions used in calculation of the SOC score. If necessary, participants were offered assistance in completing the questionnaire. To avoid potential reverse causality, i.e. presence of diabetic complications influencing SOC, participants with diabetic complications were not included in the present study, leaving a study sample of 125 patients with long-standing type 1 diabetes but free of complications.

Assessment of Sense of Coherence

SOC was evaluated using the 13-item version of Antonovsky's scale measuring the three dimensions of SOC, which are, meaningfulness, comprehensibility and manageability in a single scale [12]. The SOC scale has been widely used and validated in various cross-cultural settings [3]. The participants were asked to indicate their agreement with each question on a 7-point scale. The 13 individual scores were summarized into a full continuous scale ranging from 13 to 91 with higher scores indicating higher SOC. To improve interpretability of the scale a linear transformation was performed where 0 was made equal to the mean of the population and one unit corresponding to one standard deviation of the population. Previous studies, dividing SOC into tertiles or quartiles, have found non-linear associations between SOC and diabetes management [1]. Thus we anticipated the possibility of non-linear associations between SOC and the outcomes in this study. To account for potential non-linear associations we used SOC as a continuous scale in the statistical models whilst testing models for linearity and when necessary applying models to analyse non-linear associations.

Clinical risk factors

HbA_{1c}, systolic blood pressure, diastolic blood pressure, LDL cholesterol, HDL cholesterol, and triglycerides were measured using routine clinical measurement methods.

Statistical analyses

Descriptive statistics are presented as means (SD). We applied multiple linear regression modelling to study the associations between SOC and clinical risk factors adjusting for possible confounding by sex, age and diabetes duration. Following test for linearity, the associations were analysed using a standard linear regression model. In cases of non-linearity, we applied generalized additive models utilizing splines in order to take non-linearity into account [16]. As the moderate number of participants only allowed for limited flexibility, the non-linear associations were modelled with 3 degrees of freedom. In order to fulfil the requirement for a normal distribution of residual errors, some outcomes (HbA_{1c}, systolic blood pressure, HDL-C, and triglycerides) were log-transformed prior to analysis. All statistical analyses were performed using SAS 9.2 (SAS Institute, Cary NC).

Results

Out of the 183 patients included in the Steno Diabetes Center arm of the PROLONG study, we excluded patients with complications and with missing data on key variables, rendering a population of 120 patients for the current study. Mean SOC score was 71.3 (standard deviation (SD) = 11.5) before transformation of the scale.

Table 1 shows descriptive statistics of the study population. The population was 58% women. More than 75% of the sample reported to be graduates from a higher education and 79% reported to be in a relationship. Only 5% of the population reported sedentary lifestyle. The mean diabetes duration was 41 years (SD = 7.9) and the mean age was 60.7 (SD = 9.6).

Table 2 shows the distribution of clinical risk factors measured in the population. Data on cholesterol and triglyceride was missing for 9 participants. Mean HbA_{1c} was 7.5%, whilst 37 (30%) participants were at or below 7.0% and therefore considered well-regulated according to Danish healthcare guidelines. High variations of blood pressure, cholesterol, and triglycerides were observed.

In linear regression analyses adjusted for diabetes duration and sex, no statistically significant associations were observed between SOC and clinical biomarkers (Table 3). As non-linear associations were observed in models with LDL-C and total cholesterol as outcomes, those results are omitted from Table 3 and instead presented in Fig. 1 only.

Fig. 1 shows the non-linear associations between SOC and the non-transformed outcome variables. The graph shows the combined linear and non-linear impact on SOC with the value 0.0 corresponding to the average impact of SOC on the outcome, i.e. the average participant is used as reference. As seen in Fig. 1e, medium and high SOC is associated with lower levels of LDL-C. Thus, the estimated impact of SOC on LDL-C does not differ between medium and high levels of SOC. A flat or even slightly attenuated LDL-C among participants with highest SOC can also be seen in the figure. This indicates no further impact on LDL-C from increasing SOC

Table 1
Descriptive statistics for the study population (N = 125).

	N	*%*
Women	70	58
In relationship	93	79
Higher Education	88	75
Active lifestyle (moderate/high level of exercise)	109	95
	Mean	SD
Age (years)	60.7	9.6
Diabetes duration (years)	41.2	7.9
Sense of Coherence (SOC)	71.3	11.5

Table 2
Outcome measures.

Variable	n	Mean	SD	(min–max)
HbA1c (%)	120	7.5	0.9	(5.7–10.7)
Systolic BP (mmHg)	120	129.3	16.1	(98–178)
Diastolic BP (mmHg)	120	76.0	9.3	(54–104)
HDL-C (mmol/l)	111	1.8	0.5	(0.90–3.92)
LDL-C (mmol/l)	111	2.6	0.7	(1.2–4.9)
Triglycerides (mmol/l)	111	0.8	0.3	(0.37–2.28)
Total cholesterol (mmol/l)	111	4.8	0.8	(3.2–8.1)

Table 3
Associations between SOC and clinical biomarkers (linear regressions). β estimate indicates the estimated change in the outcome variable corresponding to one standard deviation change in SOC.

Measure: (unit)	HbA1c (%)	[a]Systolic BP (mmHg)	Diastolic BP (mmHg)	[a]HDL-C (mmol/l)	[a]Triglycerides (mmol/l)
n	120	120	120	111	111
β Estimate	−0.110	−0.0008	−0.064	0.033	0.007
95% CI (min; max)	(−0.25; 0.03)	(−0.025; 0.023)	(−2.45; 1.16)	(−0.020; 0.087)	(−0.062; 0.077)
Standard error	0.07	0.012	0.91	0.27	0.035

[a] Log-transformed scales used.

among people with already high scores. The association between SOC and LDL-C is mirrored in the associations between SOC and total cholesterol. A tendency to lower HbA_{1c} among participants with high SOC can also be observed, although this association does not reach statistical significance.

Discussion

The study population was comprised of 125 type 1 diabetes patients free of diabetic complications despite long disease duration. Participants were in general resourceful with relatively high levels of education and an active lifestyle. Patients were generally well-regulated with HbA_{1c} within or in proximity of the target range of 7.0%. With 71.2, their mean SOC was relatively high compared to findings from a recent national representative study [17]. In this study we found an association between high SOC and lower levels of LDL-C. The association was stable across models adjusting for main potential confounders. We did not observe associations between SOC and blood pressure, triglyceride, or HbA_{1c}.

LDL-C is an established risk factor for cardiovascular morbidity among people with diabetes. There is no lower limit beyond which further LDL-C lowering is not beneficial [18]. Drug treatment and better medical adherence among people with high SOC may also explain differences in cholesterol level. Prudent food choices and regular aerobic exercise have been suggested as individual means to decrease LDL-C levels and increase levels of HDL-C [19]. That is in line with the non-significant tendency to increased HDL-C levels among participants with high SOC. Low SOC has previously been shown to predict poor medical adherence [20] and unhealthy lifestyle [10]. Pharmacy tracking studies indicate that within 6 months to 1 year after having been prescribed cholesterol-lowering statins, up to 50% of patients discontinue them [21–24]; after two years, non-adherence is as high as 75% [25,26]. Among a population of type 2 patients, from the same clinic as the present study population was drawn from, one in five participants was non-adherent [27]. Thus, suboptimal diabetes management is a likely pathway through which high SOC mediates low LDL-C.

Although we observed an association between high SOC and lowered LDL-C we found no evidence for associations between SOC and triglycerides, blood pressure, and HbA_{1c}. This is somewhat surprising as the means to lower triglyceride, blood pressure, and blood glucose through self-management are highly overlapping with the means to lower LDL-C. Frequent exercise, a balanced diet and medical adherence are well-established factors whilst other behaviours such as alcohol consumption and use of tobacco also play a role. The overall good glycaemic control in the study population providing little room for variation, may explain the absence of associations with HbA_{1c}. In a post hoc analysis, we analysed the association between SOC and LDL-C adjusted for HbA_{1c}. Following adjustment for HbA_{1c}, the association was similar shaped and remained statistically significant ($p = 0.007$), indicating independent mechanisms in the control of elevated LDL-C and HbA_{1c} in addition to the previously described overlaps. Low statistical power may also be a contributing explanation for the lack of association with other lipid profiles.

To our knowledge, the association between SOC and clinical measures have only scarcely been investigated in people with diabetes and is limited to studies with glycaemic control as endpoint. Ahola et al. found an association between higher SOC and lower HbA_{1c} in a cross-sectional study of 1264 adult patients [1]. In their study, low SOC, defined as lowest quartile, was associated with poor glycaemic control also indicating particular challenges for type 1 patients with lower SOC. Unfortunately for comparison purposes the study by Aloha et al. focused on diabetic complications rather than clinical measures as outcomes. Based on a small-scale study of Hebrew participants, Cohen and Kanter suggested an association between SOC and glycaemic control with adherence as mediator [28]. In both studies, mean HbA_{1c} was considerably higher than in the present study which could explain inconsistencies in findings. Low SOC has been associated with dyslipidaemia in studies of non-diabetic populations [29,30] suggesting that the association between SOC and LDL-C may be explained by a mechanism unrelated to diabetes.

Strengths and limitations

A major strength of the present study is the inclusion of a broad range of clinical outcomes. Despite several previous studies on SOC and diabetes-related outcomes, the association between SOC and clinical measures such as cholesterol in people with diabetes, has rarely been studied. Furthermore, the use of clinical, objectively measured outcomes provided data with a high level of consistency and free of the bias due to self-reports, differential attrition, and recall bias. As all patients were treated at the same diabetes clinic (Steno Diabetes Center), we avoided a population of people under

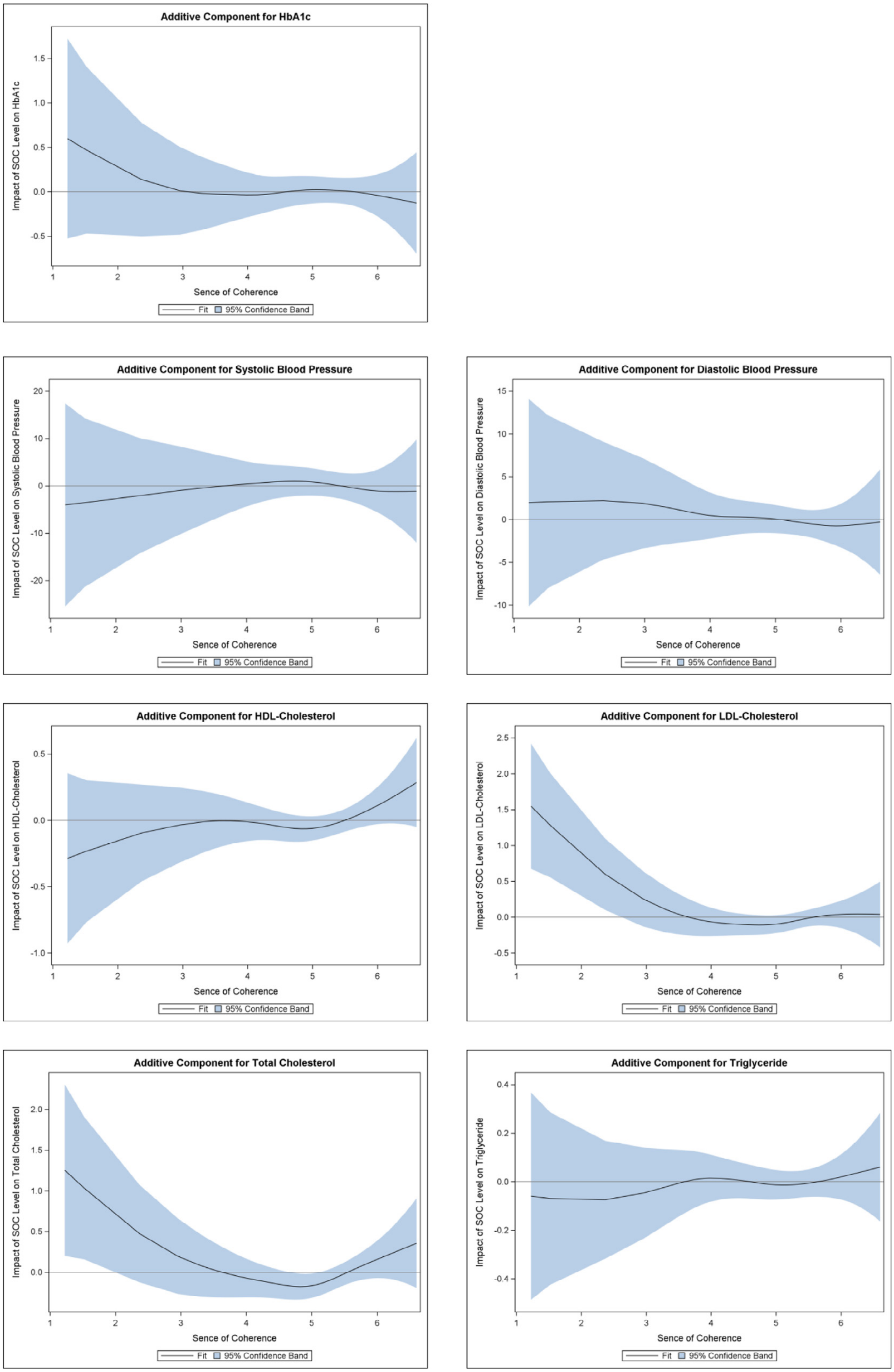

Fig. 1. Impact of Sense of Coherence on clinical outcomes.

different treatment regimens which would be a potential source of bias. The cross-sectional design prohibits any inference regarding a potential causal relationship between SOC and the clinical outcomes. However, as SOC is a construct that is assumed to remain relatively stable throughout the adult life [12], it is also assumed that SOC is the predictor of the clinical outcomes. Another limitation is the limited number of participants which does not allow us to perform informative analyses of sub-groups. Further studies are needed to identify potential protective characteristics among patients at enhanced risk of elevated cholesterol.

Antonovsky assumed that SOC is relatively stable throughout adulthood [2] although some later studies have suggested that SOC may change over time [31–33]. Thus, SOC is not a feasible direct target for interventions with aim of improving self-management among people with chronic disease. However, people with low SOC can be targeted with interventions to improve self-management and social support to compensate for low SOC in successful diabetes management. Perceived social support has found to be a health promoting factor [34] and has also been associated with improved health behaviour among people with diabetes [35].

Conclusions

In conclusion, medium and high SOC was associated with lowered LDL-C in this population of patients with long-standing type 1 diabetes and free of complications. Future studies and interventions should focus on vulnerable patients, as identified by the SOC instrument, in prevention, detection, and treatment of elevated cholesterol levels.

Ethics

The study was approved by Scientific-Ethical Committee for the Capital Region of Denmark (Hillerød, Denmark; protocol number H-2-2013-073). Written informed consent was obtained from all participants.

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Conflict of interest

The authors are employed by Steno Diabetes Center A/S, a research hospital working in the Danish National Health Service and owned by Novo Nordisk A/S. Steno Diabetes Center receives part of its core funding from unrestricted grants from the Novo Foundation and Novo Nordisk.

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