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The COVID-19 pandemic has negatively affected health behaviours in those with pre- heart failure

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Abstract

Aim

This study aims to understand the relationship between those at risk of heart failure (HF) and those with pre-heart failure (pre-HF) with Life's Simple 7 (LS7) (not smoking, a healthy body mass index (BMI), diet, physical activity (PA), blood glucose, blood pressure and cholesterol control) during COVID-19.

Methods

Prospective LS7 data from clinic were collected during COVID-19 to compare LS7 in those at risk and with pre-HF. A subset of high risk pre-HF patients also completed a questionnaire assessing pandemic behavioural change.

Results

LS7 data on 172 patients (age 70.2 [SD 10.4] years; 96 [56%] male; 77 [45%] pre-HF; median BNP 29 [IQR 15-89] pg/mL) were obtained. There was no difference in LS7 scores between those at risk of HF and those with pre-HF in adjusted analyses (OR 1.04, 95% confidence interval [CI] 0.06, 18.4).

In 50 pre-HF patients, 98% reported at least one additional unhealthy behaviour during COVID-19. Weight gain (52%), with an average of 4.4kg increase over 12 months and unhealthy diet (48%) were most frequently reported. There was a significant reduction in PA during COVID-19; with a reduction from 46% to 30% of patients achieving World Health Organisation PA recommendations.

Discussion

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COVID-19 was associated with increased self-reported unhealthy behaviours amongst pre-HF patients which could impact their risk of progression to HF.

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Introduction

Heart Failure (HF) affects around 2% of the population in Ireland and this increases to around 15% of those aged above 85 years old[1]. It costs the healthcare system over €660 million a year[2]. Recent 2022 American Heart Association heart failure (HF) guidelines, advocate for risk factor management, specifically targeting healthy lifestyle behaviours, in those at risk of HF and those with pre-heart failure (pre-HF)[3]. Those at risk of HF are asymptomatic but have cardiovascular risk factor(s) and are on a continuum of potential progression to pre-HF and subsequently, symptomatic HF. Those with pre-HF are asymptomatic, have never been diagnosed with HF before, but have structural or functional changes within the heart[3].

"Life's Simple 7" (LS7) are modifiable health characteristics and behaviours that if positively modified protect against incident HF[4] as well as other major cardiovascular adverse events[5]. LS7 include measurements of: smoking status, body mass index (BMI), physical activity (PA) level, diet, blood glucose levels, blood pressure (BP) and total cholesterol. Improving the composite of these risk factors is an important target in those at risk and with pre-HF, as these patients are already at a higher risk of symptomatic HF and other adverse cardiovascular events compared to the general population[6, 7].

During the COVID-19 pandemic, population health behaviours were affected due to confinement regulations to curb disease spread[8, 9]. Lack of sleep and excess alcohol intake also affect risk of cardiometabolic disease[10, 11] and both increased during the COVID-19 pandemic in the healthy population[9]. Understanding how behaviours may be adapted and which require more focus, during a pandemic is important for patient management, service development and public health initiatives.

This study has two aims. Firstly to compare patient reported health characteristics and behaviours, as measured by LS7, in a cohort of patients at risk of HF and with pre-HF during the COVID-19 pandemic. Secondly, it aims to understand self-reported change in health behaviours pre- COVID-19 and during COVID-19 amongst higher risk, pre-HF patients.

Methods

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We assessed health behaviours (as measured by LS7) in 2 populations; those at risk of HF, and those with pre-HF and used univariate and multivariable analyses to compare overall LS7 scores in both groups. Patients were recruited, from the STOP-HF service[12], a specialised disease management unit that screens and treats those at risk and with pre-HF.

Pre-specified covariates for multivariable modelling were age, gender, hypertension, diabetes, obesity and ischaemic heart disease. In addition, in a subgroup of high risk pre-HF patients (n=50, BNP >50pg/mL), we assessed self-reported change in health behaviours (measured by LS7, self-reported alcohol intake and sleep patterns) comparing pre-COVID-19 and during COVID-19 results using a questionnaire that took approximately 20 minutes to complete. Patients were selected for the interview if they provided informed consent and if they met criteria for pre-HF as defined by the Universal Classification of HF[13] and had a BNP >50pg/mL. The St Vincent's University Hospital Research Ethics Committee approved this study (ref:RS21-024).

Table 1 demonstrates LS7 scoring table which was taken from the REGARDS study[14].

Table 1. Life's Simple 7 scoring chart

Component	Ideal (2 points)	Intermediate (1 point)	Poor (0 points)
Smoking	Never or Former >1 year	Former < 1 year	Current
Healthy Diet Score	4 to 5 points	2 – 3 points	0 – 1 points
Physical Activity	≥4 bouts per week of intense physical activity sufficient to work up a sweat	1 -3 bouts per week of intense physical activity sufficient to work up a sweat	No intense physical activity sufficient to work up a sweat
Body Mass Index	<25 kg/m^2	25 – 29.9 kg/m^2	>30 kg/m^2
Blood Pressure	120 / <80 mmHg untreated	SBP 120 – 139 or DBP 80-89mmHg	SBP >140 or SBP >90 mmHg

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Total Cholesterol	<5.18 mmol/L untreated	5.18 – 6.19 or treated to ideal level	>6.22mmol/L
Fasting Glucose	<5.55mmol/L untreated	5.55 to 6.94 mmol/L or treated to ideal level	≥6.99 mmol/L

Guide:
Ask the patient on an average day what is their intake of each of the following:
*Healthy diet score = (1) Fruits and vegetables ≥ 4.5 cups/day. (2) Fish ≥ 200g (2 medium portions)per week (3) fibre rich whole grains (kamut, teff, pearl barley, quinoa, whole-wheat pasta, buckwheat, oatmeal, whole wheat bread, and brown rice) 3x 30 gram (1 ounce) portions /day. (4) salt <1500mg/day ($^2/_3$ a teaspoon), (5) sugar sweetened beverages (1 litre/week).

†Physical activity is measured by asking the question "How many times per week do you undertake moderate intensity of physical activity lasting 30 minutes, enough to work up a sweat, where you may be able to talk, but not sing?"

For blood pressure, please measure on 3 occasions and BPM if performed.
For non-diabetic patients, assume fasting glucose is normal unless HbA1c is elevated.

Table 1 demonstrates LS7 scoring chart as taken from the REGARDS study[14]. All patients were scored out of 2 for each component of LS7, with the higher the score (out of 0, 1, 2) the better the healthy behaviour. A maximum score of 14 and a minimum of 0 was possible.
Abbreviations: SBP = systolic blood pressure; DBP = diastolic blood pressure.

Total score. ____/14

Multivariable logistic regression was used to compare LS7 scores between at risk and pre-HF patients with adjustment for the following pre-specified covariates: age, gender, diabetes, hypertension, obesity and ischaemic heart disease. Within group comparisons were conducted using paired samples t-tests and Wilcoxon signed rank tests. Crosstabulation with Chi Squared analyses were used to compare categorical variables between groups. Phi coefficient was used for assessing effect size of Chi Squared associations, with an effect value of 0.1 = small effect, 0.3 = moderate effect, 0.5 = large effect size[15]. All statistical tests were two-tailed with a P-value of 0.05 defining statistical significance and all analyses were performed using SPSS V27 and R version 3.6.2.

Based on the REGARDS study[14], we hypothesised that there would be a 1 unit difference in LS7 between those at risk of HF and pre-HF patients, as the STOP-HF programme is more aggressive at managing risk factors in those with pre-HF. Assuming an average LS7 score of 8.0 (SD 2.0) for lower risk patients, a 2:1 proportion of lower: higher risk patients, a two sided alpha of 0.05 and 80% power, we required 141 evaluable patients. A healthcare professional, objectively scored clinic derived data on LS7, prospectively, on 172 consecutive patients between October 2020 – May 2021, until the sample size requirements were met. All patients were included who could provide informed consent. In addition, the in-depth questionnaire (enrolling higher risk pre-HF patients), aimed to enrol as many pre-HF patients with a BNP

>50pg/mL as possible during level 5 Covid 19 lockdown restrictions in 2021. This questionnaire relied on subjective patient reported data on health behaviours which included self-reported weight gain and the International Physical Activity Questionnaire (Long Form).

Results

The main results are reported in Table 2. Males comprised 55.8% and there was a mean age of 70.2 (SD 10.4) years. Mean LS7 score was 7.84 (SD 2.16) which represents an intermediate healthy cohort[14]. The population was predominantly overweight or obese (mean BMI was 29.7 (SD 5.9) kg/m$^{2)}$. Median BNP was 29 (IQR 15 - 89) pg/mL, which overall represents moderate risk (BNP < 20 pg/mL = low risk, 20-49 pg/mL = moderate risk and ≥50 pg/mL = high risk[12]). Pre-HF patients were older, had higher BNP levels and were more likely to have atrial fibrillation as well as abnormalities on Doppler-echocardiography.

Overall, there was no difference between LS7 scores between those at risk of HF and pre-HF patients in univariate or multivariable analyses (OR 1.04, 95% confidence interval [CI] 0.06, 18.4). In further analyses, there was no association between pre-HF risk status and individual components of the LS7 scores, except for smoking status. Pre-HF patients were less likely to smoke (OR 0.53, 95% CI 0.29, 0.94).

Table 2: Patient characteristics and Life's Simple 7 (LS7) scores of those at risk of HF and those with pre-HF during the COVID-19 pandemic

	All Patients N=172	At risk of HF N=95	Pre-HF N=77	P Value	N
Age, years	70.2 (10.4)	67.4 (10.3)	73.7 (9.48)	<0.001	172
Male, n (%)	96 (55.8%)	54 (56.8%)	42 (54.5%)	0.883	172
BMI Category:				0.870	172
Normal, n (%)	30 (17.4%)	16 (16.8%)	14 (18.2%)		
Obese, n (%)	74 (43.0%)	39 (41.1%)	35 (45.5%)		
Overweight, n (%)	66 (38.4%)	39 (41.1%)	27 (35.1%)		

Underweight, n (%)	2 (1.16%)	1 (1.05%)	1 (1.30%)		
Hypertension, n (%)	151 (87.8%)	81 (85.3%)	70 (90.9%)	0.373	172
Diabetes, n (%)	70 (40.7%)	42 (44.2%)	28 (36.4%)	0.376	172
Dyslipidaemia, n (%)	130 (75.6%)	67 (70.5%)	63 (81.8%)	0.125	172
Previous Stroke, n (%)	8 (4.65%)	3 (3.16%)	5 (6.49%)	0.469	172
Atrial Fibrillation, n (%)	21 (12.2%)	5 (5.26%)	16 (20.8%)	0.004	172
CKD, n (%)	29 (16.9%)	12 (12.6%)	17 (22.1%)	0.150	172
IHD, n (%)	25 (14.5%)	9 (9.47%)	16 (20.8%)	0.061	172
HbA1c, mmoL/mmoL	46.2 (13.0)	45.7 (10.7)	46.8 (15.5)	0.621	154
BNP, pg/mL	29.3 [15.2;88.6]	19.7 [7.90;44.2]	68.5 [31.4;132]	<0.001	172
Creatinine, mmol/L	77.5 [67.0;97.8]	75.5 [65.5;94.8]	83.0 [67.8;102]	0.266	162
Doppler echocardiography					
EF (%)	65.9 (8.30)	67.5 (6.88)	64.1 (9.48)	0.009	171
E/e'	10.1 (4.19)	8.97 (2.04)	11.5 (5.48)	<0.001	157
LAVI, mL/m²	30.9 (10.2)	25.4 (5.55)	38.0 (10.3)	<0.001	167
LVMI, g/m²	104 (29.6)	88.5 (16.1)	119 (31.8)	<0.001	100
Life's Simple Seven scores					
Mean Diet score (SD) [measured from 0 – 2]	1.41 (0.59)	1.39 (0.59)	1.44 (0.60)	0.567	172
Mean BP score (SD) [measured from 0 – 2]	0.77 (0.56)	0.79 (0.56)	0.75 (0.57)	0.676	172
Mean BMI (SD)	29.7 (5.92)	29.5 (5.53)	29.9 (6.40)	0.719	172

Mean Glucose score (SD) [measured from 0 – 2]	1.09 (0.82)	1.04 (0.82)	1.16 (0.81)	0.366	172
Mean Lipid score (SD) [measured from 0 – 2]	1.13 (0.45)	1.12 (0.46)	1.14 (0.45)	0.698	172
Mean physical activity score (SD) [measured from 0 – 2]	0.90 (0.90)	0.96 (0.89)	0.83 (0.91)	0.358	170
Mean smoking score (SD) [measured from 0 – 2]	1.77 (0.61)	1.81 (0.57)	1.72 (0.67)	0.368	171
Overall LS7 score (SD) [measured from 0 – 14]	7.84 (2.16)	7.91 (2.24)	7.75 (2.07)	0.645	172

Table 2 demonstrating baseline characteristics of patients at risk of HF and patients with pre-HF. Abbreviations: BNP = B-Type natriuretic peptide; BMI = body mass index; BP = blood pressure; CKD = chronic kidney disease; HbA1c = glycosylated haemoglobin; IHD = ischaemic heart disease. EF = Ejection Fraction, LAVI = Left Atrial Volume Index, LVMI = Left Ventricular Mass Index.

LS7 scores showed that overall, 93.0% did not have an ideal BP, 81.4% were overweight/obese and 82.6% did not have an ideal level of cholesterol. Not smoking (87.1%) and a healthy diet (46.5%) were the most common patient reported health behaviours during the COVID-19 pandemic. Figure 1 demonstrates each LS7 frequency in the total population. A low BNP was significantly ($P<0.05$) associated with BMI. The other LS7 behaviours (diet, PA, smoking status, BP, glucose and cholesterol) as well as a composite, demonstrated no significant correlation with BNP.

Figure 1. Distribution of health behaviours in at risk and pre-heart failure patients during the COVID-19 pandemic

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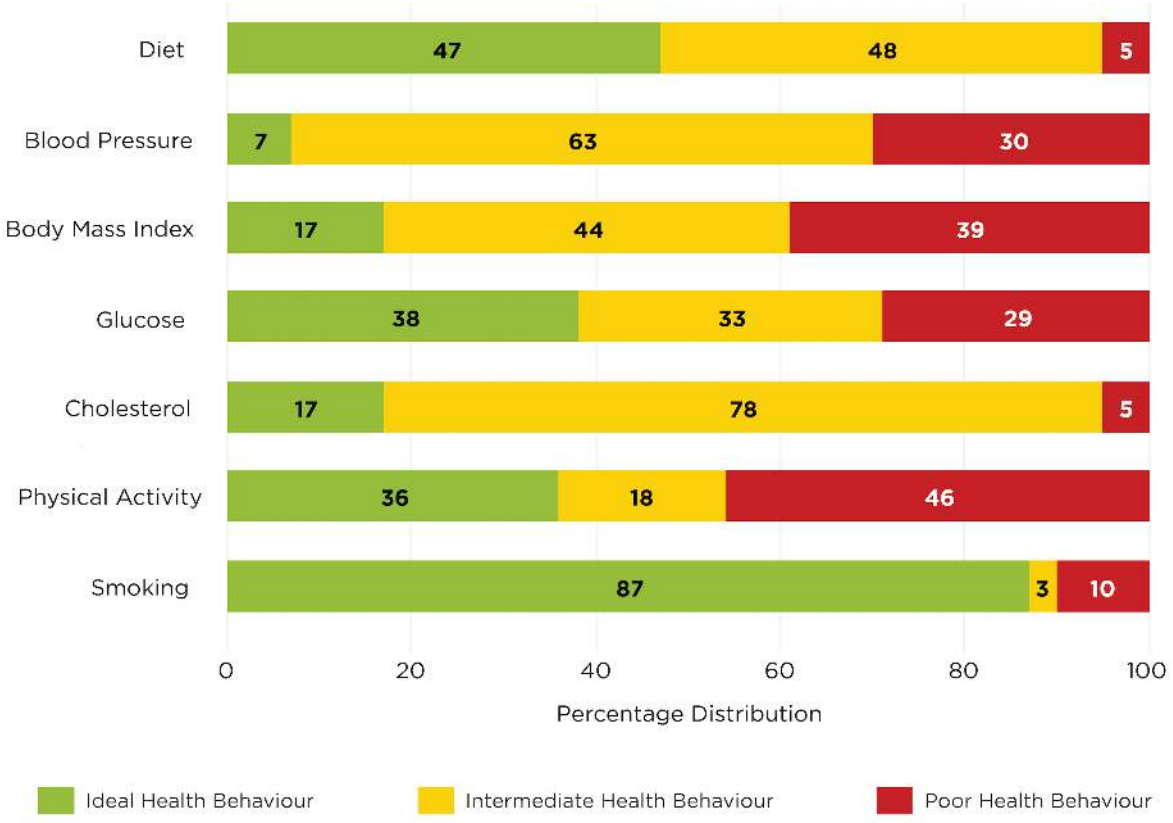

Figure 1 demonstrates LS7 scores (ideal, intermediate or poor) in those at risk of heart failure and those with pre-HF during COViD-19 (n= 172). Abbreviations: BMI = Body Mass Index; BP, blood pressure; PA = Physical Activity

Evaluation of LS7 before and during COVID-19 in the high risk pre-HF subgroup

The second stage of the study, focused on changes in health and behaviour in a subgroup of high risk pre-HF patients (median BNP = 78.9 [IQR 39 - 171] pg/mL) before and during COVID-19. Around a third (30%) of high risk patients reported that their health was affected by COVID-19, of which 60% stated this was due to worsening of mental health. Despite only 30% reporting that their health had been affected, when asked specifically about adopting more unhealthy behaviours during COVID-19, 98% of patients reported adopting at least one additional unhealthy behaviour. During COVID-19, a third of high risk patients had missed routine outpatient appointments with the main reasons being the hospital cancelling the appointment (65%) and patient concern over safety visiting a hospital (24%).

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The majority of high risk pre-HF patients reported an increase in unhealthy dietary intake (54%) and weight gain (52%) of which there was an average of 4.4kg increase over 12 months. A further 48% reported less physical activity (48%) and patient perceived worsening BP control (40%). (Of note, STOP-HF patients are encouraged to have their own home BP monitor). There were no significant differences between behavioural changes in males and females before and during COVID-19.

Figure 2 demonstrates the change in patient reported PA before and during COVID-19 as measured by the International Physical Activity Questionnaire. There was a significant reduction in walking ($p < 0.05$) by 72 minutes per week (from 304 min to 232 min) and vigorous PA ($p < 0.05$) by 26 minutes per week (from 33 min to 7) during COVID-19 compared to pre-COVID-19. There was no significant difference in moderate PA ($p = 0.20$) though it reduced by 48 minutes/week. During COVID-19, there was a significant reduction ($p < 0.05$) from 46% to 30% of patients who reached World Health Organisation recommended PA guidelines (≥ 150 minutes of moderate PA or ≥ 75 minutes of vigorous PA per week) compared to pre-COVID-19 with a moderate effect size (Phi effect size = 0.36). Patient reported sedentary time pre-COVID-19 (4 hours) was not significantly different during COVID-19 (5 hours).

Figure 2: Perceived change in minutes per week of different intensities of physical exercise during COVID-19 in high risk pre-heart failure patients with elevated BNP (BNP > 50 pg/mL) Abbreviations: BP, blood pressure; PA = Physical Activity

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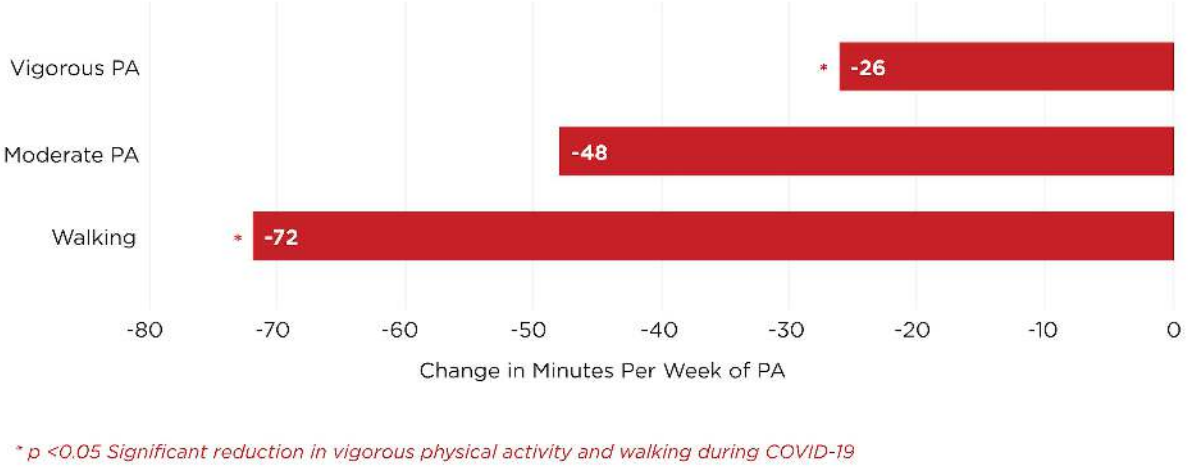

Figure 2 demonstrates patient reported change in physical activity before and during COVID-19.
Abbreviations: BP, blood pressure; PA = Physical Activity

The majority of patients (80%) had not previously undertaken an exercise programme before, but 46% of patients reported an interest in remote exercise prescription either through a text based or App based service. There was a significant association ($p<0.001$) with a large effect (Phi effect size of 0.517) of those who were interested in an mHealth intervention to improve PA and those who were not meeting WHO recommended PA guidelines.

Discussion

This is the first study to look at LS7 in patients identified as at risk of HF and those with pre-HF during COVID-19. Those with pre-HF reported increased unhealthy behaviours which could impact their risk of progression to HF. Despite advice to focus on self-care and good health behaviours, especially amongst higher risk pre-HF patients, during the COVID-19 pandemic, we found no difference in self-reported LS7 scores between at risk and pre-HF patients. There was no relationship observed between LS7 scores and BNP levels. Nor did we find differences in the individual components of these scores with the exception of smoking status, which was significantly lower amongst pre-HF patients.

Poor LS7 scores are associated with incident hypertension[14], atrial fibrillation[16], HF[17] and other major cardiovascular events[18]. Understanding the proportion of unhealthy behaviours in those at risk of HF and with pre-HF allows focus to be placed on areas of most need. We found that BP control, healthy BMI and cholesterol control were the least adhered to overall. When forming strategies to improve such health behaviours, it must be recognised that improving health behaviours such as weight loss or engaging in physical activity is challenging for many patients despite adequate support.

The lack of correlation of LS7 composite between each group or BNP is likely related to a complex interplay between the individual health behaviours. BNP is well known to be lower in those with a high BMI[19], hypothesised due to increased clearance of BNP by adipose tissue. Elevated BMI related to obesity, in turn, is often associated with an unhealthy diet or high cholesterol[20], which may therefore confound the association between negative health behaviours from being positively associated with BNP. We expected patients with pre-HF to adhere to more positive health behaviours given the higher intensity of management (more frequent visits, higher risk of adverse events highlighted and closer monitoring of BP/cholesterol and glucose) through the STOP-HF unit. This highlights one of the intrinsic flaws with the LS7 scoring system when comparing those at lower cardiovascular risk with those at higher risk. Those who are on anti-hypertensive or lipid lowering therapy automatically get scored as “1” or “intermediate” even if their blood pressure or cholesterol levels are in the ideal target range. As risk increases, it is likely patients will be placed onto therapy such as anti-hypertensives / lipid lowering therapy. However those who are lower risk, may not warrant anti-hypertensive or lipid lowering therapy, despite having elevated blood pressure or cholesterol, as their overall risk is low. Therefore, both patients who are higher risk but on appropriate therapy and those who are lower risk but who are not on therapy (but have elevated BP or cholesterol) would receive the same LS7 score.

Patient reported PA was significantly ($p < 0.05$) affected by COVID-19 with a 24% reduction in walking and a 79% reduction in vigorous PA. Despite this, overall PA levels in the form of walking were high (232 minutes/week and 304 minutes / week), but vigorous PA (7 minutes/week and 33 minutes/week) was low both during and pre-COVID-19. This mirrors other studies which suggests that the exercise preferred by older adults is walking[21] and that there is less time spent on vigorous PA[22, 23]. In population studies looking at PA during COVID-19, there was early evidence of a reduction in PA due to confinement[24]. A strength of this study was recruiting the high risk pre-HF subgroup 1 year after the initial COVID-19

restrictions were introduced, as this provided 12 months for potential adaptive behaviours to occur.

There are several possible reasons as to why there were decreased health behaviours in patients with pre-HF during COVID-19. The national guidelines for confinement meant there was a lack of facilities and opportunities to undertake exercise (such as gyms, classes or sporting events) or attend weight support groups (5 km travel restriction). Additionally, there was less contact with health care professionals, thereby potentially reducing the "nudge theory" of positive behaviour[25].

As with most studies involving LS7, a limitation of this study relies on patient reported responses and this may not accurately reflect actual health behaviours. For example, self-reported PA and objectively measured activity using accelerometers only modestly correlate[26]. This study did not explore the relationship of socio-economic status which is associated with health behaviours[27], however the STOP-HF unit has a relatively homogenous population due to the recruitment of patients from nearby geographic locations. Finally, there was also a relatively small number of patients enrolled, which may contribute to the lack of significant correlation between LS7 and BNP.

In summary, during COVID-19 there was no difference between LS7 in patients at risk of HF and those with pre-HF. There was no association between a composite of LS7 and BNP in patients at risk of HF or those with pre-HF. Almost all (98%) high risk pre-HF patients reported significantly worse health behaviours during COVID-19. These negative health behaviours exacerbated by COVID-19, could have an impact on progression of symptomatic HF and other adverse cardiovascular events post-COVID-19.

Declarations of Conflicts of Interest:

None declared.

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References:

1. HealthServiceExecutive. Living with Heart Failure https://www.hse.ie/eng/health/hl/living/heartfailure/2023 [Health Service Informational Website for Ireland]. Available from: https://www.hse.ie/eng/health/hl/living/heartfailure/.
2. RTE. The Cost of Heart Failure https://www.rte.ie/documents/news/cost-of-heart-failure-report-web.pdf2015 [Available from: https://www.rte.ie/documents/news/cost-of-heart-failure-report-web.pdf.
3. Heidenreich PA, Bozkurt B, Aguilar D, Allen LA, Byun JJ, Colvin MM, et al. 2022 AHA/ACC/HFSA Guideline for the Management of Heart Failure: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation. 2022:101161CIR0000000000001063.
4. Uijl A, Koudstaal S, Vaartjes I, Boer JMA, Verschuren WMM, van der Schouw YT, et al. Risk for Heart Failure: The Opportunity for Prevention With the American Heart Association's Life's Simple 7. JACC Heart Fail. 2019;7(8):637-47.
5. Fang N, Jiang M, Fan Y. Ideal cardiovascular health metrics and risk of cardiovascular disease or mortality: A meta-analysis. Int J Cardiol. 2016;214:279-83.
6. Daniels LB, Clopton P, Jiang K, Greenberg B, Maisel AS. Prognosis of stage A or B heart failure patients with elevated B-type natriuretic peptide levels. J Card Fail. 2010;16(2):93-8.

7. McKie PM, Cataliotti A, Lahr BD, Martin FL, Redfield MM, Bailey KR, et al. The prognostic value of N-terminal pro-B-type natriuretic peptide for death and cardiovascular events in healthy normal and stage A/B heart failure subjects. J Am Coll Cardiol. 2010;55(19):2140-7.
8. Ammar A, Brach M, Trabelsi K, Chtourou H, Boukhris O, Masmoudi L, et al. Effects of COVID-19 Home Confinement on Eating Behaviour and Physical Activity: Results of the ECLB-COVID19 International Online Survey. Nutrients. 2020;12(6).
9. Stanton R, To QG, Khalesi S, Williams SL, Alley SJ, Thwaite TL, et al. Depression, Anxiety and Stress during COVID-19: Associations with Changes in Physical Activity, Sleep, Tobacco and Alcohol Use in Australian Adults. Int J Environ Res Public Health. 2020;17(11).
10. Knutson KL. Sociodemographic and cultural determinants of sleep deficiency: implications for cardiometabolic disease risk. Soc Sci Med. 2013;79:7-15.
11. Arnett DK, Blumenthal RS, Albert MA, Buroker AB, Goldberger ZD, Hahn EJ, et al. 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Circulation. 2019;140(11):e563-e95.
12. Ledwidge M, Gallagher J, Conlon C, Tallon E, O'Connell E, Dawkins I, et al. Natriuretic peptide-based screening and collaborative care for heart failure: the STOP-HF randomized trial. JAMA. 2013;310(1):66-74.
13. Bozkurt B, Coats A, Tsutsui H. Universal Definition and Classification of Heart Failure. J Card Fail. 2021.
14. Plante TB, Koh I, Judd SE, Howard G, Howard VJ, Zakai NA, et al. Life's Simple 7 and Incident Hypertension: The REGARDS Study. J Am Heart Assoc. 2020;9(19):e016482.
15. Cohen J. Statistical power analysis for the behavioral sciences1988.
16. Ogunmoroti O, Michos ED, Aronis KN, Salami JA, Blankstein R, Virani SS, et al. Life's Simple 7 and the risk of atrial fibrillation: The Multi-Ethnic Study of Atherosclerosis. Atherosclerosis. 2018;275:174-81.
17. Ogunmoroti O, Oni E, Michos ED, Spatz ES, Allen NB, Rana JS, et al. Life's Simple 7 and Incident Heart Failure: The Multi-Ethnic Study of Atherosclerosis. J Am Heart Assoc. 2017;6(6).
18. Diez-Espino J, Buil-Cosiales P, Babio N, Toledo E, Corella D, Ros E, et al. Impact of Life's Simple 7 on the incidence of major cardiovascular events in high-risk Spanish adults in the PREDIMED study cohort. Rev Esp Cardiol (Engl Ed). 2020;73(3):205-11.
19. Madamanchi C, Alhosaini H, Sumida A, Runge MS. Obesity and natriuretic peptides, BNP and NT-proBNP: mechanisms and diagnostic implications for heart failure. Int J Cardiol. 2014;176(3):611-7.

20. Klop B, Elte JW, Cabezas MC. Dyslipidemia in obesity: mechanisms and potential targets. Nutrients. 2013;5(4):1218-40.
21. Clemente Remon AL, Jimenez Diaz-Benito V, Jimenez Beatty JE, Santacruz Lozano JA. Levels of Physical Activity Among Older Adults in the European Union. J Aging Phys Act. 2020;29(2):242-9.
22. van Ballegooijen AJ, van der Ploeg HP, Visser M. Daily sedentary time and physical activity as assessed by accelerometry and their correlates in older adults. Eur Rev Aging Phys Act. 2019;16:3.
23. Harris TJ, Owen CG, Victor CR, Adams R, Cook DG. What factors are associated with physical activity in older people, assessed objectively by accelerometry? Br J Sports Med. 2009;43(6):442-50.
24. Castaneda-Babarro A, Arbillaga-Etxarri A, Gutierrez-Santamaria B, Coca A. Physical Activity Change during COVID-19 Confinement. Int J Environ Res Public Health. 2020;17(18).
25. Kwan YH, Cheng TY, Yoon S, Ho LYC, Huang CW, Chew EH, et al. A systematic review of nudge theories and strategies used to influence adult health behaviour and outcome in diabetes management. Diabetes Metab. 2020;46(6):450-60.
26. Prince SA, Adamo KB, Hamel ME, Hardt J, Connor Gorber S, Tremblay M. A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. Int J Behav Nutr Phys Act. 2008;5:56.
27. Morkevicius V, Norkus Z, Markeviciute J. Risky health behaviours and socioeconomic inequalities in European countries: new insights from European Social Survey. Cent Eur J Public Health. 2020;28(4):251-9.