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Clinical Research

Impact of Yoga on Global Cardiovascular Risk as an Add-On to a Regular Exercise Regimen in Patients With Hypertension

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ABSTRACT

Background: We aimed to determine whether the addition of yoga to a regular exercise training regimen improves cardiometabolic risk profile.

Methods: Sixty individuals with diagnosed hypertension (≥ 140/90 mm Hg for 3 measurements on different days) were recruited in an exercise training program. In addition to aerobic exercise training, participants were randomised into either a yoga or a stretching control group. Participants, over the 3-month intervention regimen, performed 15 minutes of either yoga or stretching in addition to 30 minutes of aerobic exercise training 5 times weekly. Blood pressure, anthropometry, high-sensitivity C-reactive protein (hs-CRP), glucose, and lipid levels as well as the Framingham and Reynolds Risk Scores were measured.

RÉSUMÉ

Contexte : Nous avons cherché à déterminer si l'ajout du yoga à un programme d'entraînement physique régulier pouvait améliorer le profil de risque cardiométabolique.

Méthodologie : Soixante personnes ayant reçu un diagnostic d'hypertension (trois mesures ≥ 140/90 mmHg prises lors de journées différentes) ont été recrutées pour participer à un programme d'entraînement comprenant, en plus des exercices aérobies au lieu de aérobiques, soit une séance de yoga soit une séance d'étirements (le groupe témoin), les participants étant répartis aléatoirement dans l'un des deux groupes. Sur une période de trois mois, les participants ont effectué 15 minutes de yoga ou d'étirements en plus des 30 minutes d'exercices aérobies au lieu de aérobiques, à raison de cinq fois par semaine. Les paramètres

Yoga is a multifaceted lifestyle activity that can positively enhance cardiovascular health and well-being.[1] Physical exercises such as stretching and the physical components of yoga practices have several similarities, but important differences. Evidence suggests that yoga interventions appear to be equal or superior to exercise regarding cardiovascular outcomes.[2] However, there is considerable variability in yoga types, components, frequency, session length, intervention duration, and intensity.[3]

Yoga can be a viable intervention to reduce inflammation across a multitude of chronic conditions, including heart disease.[4] The use of yoga for controlling high blood pressure is an increasingly popular intervention and has been used in diverse clinical settings.[5,6] In addition, there is evidence showing other beneficial physiologic and clinical impacts of yoga on the cardiovascular system as well as the potential role of yoga as a component of a comprehensive cardiac rehabilitation program.[7,8]

Some have argued that the cardiovascular benefits of yoga may come primarily from the stretching components of yoga.[2] Despite a large number of clinical trials on the effects of yoga on hypertension, there are no studies that have compared the impact of yoga vs stretching in addition to a regular exercise training regimen in patients with hypertension.[5] The aim of

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Results: At baseline, there was no difference in age, sex, smoking status, body mass index, blood pressure, heart rate, lipid and glucose levels, and Framingham Risk Score between groups. After the 3-month intervention period, the decrement in systolic and diastolic blood pressures (before vs after stretching: 126 ± 11/76 ± 7 vs 122 ± 11/73 ± 8 mm Hg; before vs after yoga: 130 ± 13/77 ± 10 vs 119 ± 11/69 ± 8 mm Hg) and heart rate was greater ($P < 0.001$) in the yoga group, with similar decreases in lipid, glucose, and hs-CRP levels and Framingham Risk Score in both groups. Reynolds Risk Score decrement was higher in the yoga vs the control group (absolute reduction −1.2 ± 1.2 vs −0.6 ± 0.8; relative reduction 13.2 ± 11.8% vs 9.3 ± 6.5%; $P < 0.05$).

Conclusion: In patients with hypertension, the practice of yoga incorporated in a 3-month exercise training program was associated with greater improvement in resting blood pressure and heart rate and Reynolds Risk Score compared with stretching.

Résultats : Au début de l'étude, il n'y avait aucune différence entre les groupes sur le plan de l'âge, du sexe, du statut tabagique, de l'indice de masse corporelle, de la pression artérielle, de la fréquence cardiaque, des taux de lipides et de glucose ou du score de risque de Framingham. Après la période d'intervention de trois mois, les baisses de la pression artérielle systolique et diastolique (avant *vs* après les séances d'étirements : 126 ± 11/76 ± 7 *vs* 122 ± 11/73 ± 8 mmHg; avant *vs* après les séances de yoga : 130 ± 13/77 ± 10 *vs* 119 ± 11/69 ± 8 mmHg) et de la fréquence cardiaque étaient plus marquées ($P < 0,001$) dans le groupe pratiquant le yoga; les diminutions des taux de lipides, de glucose et de PCR-hs et du score de risque de Framingham étaient équivalentes dans les deux groupes. La diminution du score de risque de Reynolds était plus importante dans le groupe pratiquant le yoga que dans le groupe témoin (diminution absolue de −1,2 ± 1,2 *vs* −0,6 ± 0,8; diminution relative de 13,2 ± 11,8 % *vs* 9,3 ± 6,5 %; $P < 0,05$).

Conclusion : Chez les patients atteints d'hypertension, la pratique du yoga dans le cadre d'un programme d'entraînement physique de trois mois a été associée à des améliorations de la pression artérielle et de la fréquence cardiaque au repos ainsi que du score de risque de Reynolds supérieures à celles obtenues avec les étirements.

the present pilot study was to determine whether the addition of yoga, compared with stretching, to a regular exercise training regimen reduces global cardiovascular risk.

Methods

Ninety-eight patients ≥ 18 years old with hypertension,[9] presenting to a regional lifestyle and cardiovascular prevention exercise rehabilitation centre, were consecutively screened, of which 60 individuals met the inclusion and exclusion criteria and provided written informed consent to be included in this pilot lifestyle exercise-based intervention study. The study was submitted to the Waterloo Wellington Science and Engineering Fair Committee for approval. The University of Waterloo Clinical Research Ethics Board gave approval to analyse data from these science fair projects for publication purposes. The University of Waterloo Research Ethics Committee approval number for this data analysis was ORE # 20980. Patients enrolled in a primary prevention program with hypertension were eligible to participate in the study. Patients with symptoms or signs of coronary artery disease and heart failure were excluded. All individuals with known or reported hypertensive end-organ damage, as well as those taking medications or supplements that affect blood pressure, cholesterol, or inflammation were also excluded. Demographic information was collected at baseline and at completion of the study 3 months later. Anthropometric parameters (weight, height) were measured at baseline and at 3 months with similar light clothing and shoes off. Participants were randomised 1 to 1 into a control group doing standard exercises with a stretching routine and a yoga group who did a yoga routine (Supplemental Table S1 and Supplemental Appendix S1) instead of the stretching component of the program (Supplemental Table S2 and Supplemental Appendix S2). In addition, all participants in both groups did an additional 30 minutes of continuous sustained moderate-intensity aerobic exercise training 5 times weekly. Participants came to the cardiac rehabilitation facility for on-site exercises twice weekly and performed the same routines at home 3 times per week for 3 months. Age-predicted target heart rate (220 minus age) was used as a measure of intensity regarding the aerobic portion of the exercise training regimen. Sixty percent of the age predicted target heart rate was selected for all participants for the aerobic exercise training portion of the program. Blood pressure (Hem 907XL IntelliSense Professional Digital Blood Pressure Monitor; Omron Healthcare, aLke Forest, IL), lipid and glucose levels, inflammatory marker (hs-CRP), Reynolds Risk Score,[10] and Framingham Risk Score[11] were assessed at baseline and at 3 months. Blood pressure was measure with the patient being rested comfortably for 5 minutes in the seated position with back support. The first reading was discarded and the latter 2 averaged as recommended by the 2020 Canadian hypertension guidelines.[9] No additional blood work was performed specifically for this study. Glycated hemoglobin (HbA_{1c}), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglyceride (TG) levels were measured at baseline and at 3 months through a local commercial laboratory (Lifelabs Canada). Measurements were performed at least 48 hours after the last bout of exercise.

Statistical analysis

The results are expressed as mean ± SD unless specified otherwise. Log transformation was used before statistical analyses for non-normally distributed data. Baseline characteristics comparisons were performed by means of Student *t* test for continuous variables and chi-square for dichotomous variables. For measurements at baseline and 3 months, linear mixed models were performed to compare groups with

interaction terms between repeated measurements and groups. A P value ≤ 0.05 was considered to be statistically significant.

Results

At baseline, there was no difference between groups in age, sex, smoking rates, body mass index, resting systolic and diastolic blood pressure, and resting heart rate and pulse pressure (Table 1). HbA_{1c} ($P = 0.02$) and hs-CRP ($P = 0.001$) levels were higher in the yoga group, whereas there was no difference in HDL-C, LDL-C, TG, and fasting glucose levels between groups (Table 1). The 10-year Reynolds Risk Score and Framingham Risk Score were similar between groups (Table 1).

After the 3-month intervention period, there was a decrease in resting systolic and diastolic blood pressure (Fig. 1), mean arterial blood pressure, and heart rate in both groups (Table 2). However, the decrement in these parameters was significantly greater in the yoga group (Table 2). There was a significant decrease in LDL-C, TG, glucose, HbA_{1c}, and hs-CRP levels and Framingham Risk Score in both groups. This decrement was not different between groups (Table 2). The changes in the absolute and the relative 10-year Reynolds Risk Score was higher in the yoga vs the control group (absolute reduction -1.2 ± 1.2 vs -0.6 ± 0.8 and relative reduction $-13.2 \pm 11.8\%$ vs $-9.3 \pm 6.5\%$; $P < 0.05$).

Table 1. Baseline characteristics

	Stretching (n = 30)	Yoga (n = 30)	P value
Age, y	63.7 ± 13.2	62.4 ± 10.3	0.69
Men (%)	21 (70)	21 (70)	1.00
Smokers (%)	3 (10)	5 (17)	0.71
Body mass index, kg/m^2	31.7 ± 3.3	32.4 ± 3.1	0.42
Systolic blood pressure, mm Hg	126 ± 11	130 ± 13	0.27
Diastolic blood pressure, mm Hg	76 ± 7	77 ± 10	0.53
Heart rate, beats/min	74 ± 11	73 ± 11	0.59
Pulse pressure, mm Hg	50 ± 10	52 ± 9	0.41
Mean arterial pressure, mm Hg	93 ± 7	95 ± 10	0.37
HDL cholesterol, mmol/L	1.26 ± 0.55	1.18 ± 0.31	0.52
LDL cholesterol, mmol/L	3.11 ± 0.42	3.19 ± 0.50	0.51
Triglycerides, mmol/L	2.32 ± 0.39	2.46 ± 0.43	0.19
Fasting blood glucose, mmol/L	5.4 ± 0.4	5.6 ± 0.6	0.15
HbA_{1c}, %	5.5 ± 0.3	5.7 ± 0.4	0.02
hs-CRP, nmol/L	2.3 ± 0.4	3.0 ± 0.9	0.001
Reynolds Risk Score	9.0 ± 2.0	8.2 ± 1.7	0.09
Framingham Risk Score	14.8 ± 9.1	15.0 ± 8.6	0.92

HbA_{1c}, glycated hemoglobin; HDL, high-density lipoprotein (HDL); hs-CRP, high-sensitivity C-reactive protein; LDL, low-density lipoprotein (HDL).

Discussion

With yoga practice becoming a widely accepted form of exercise, the body of yoga research is growing. Yoga practiced as a form of exercise, whether therapeutically or for physical fitness, warrants systematic assessment for its potential cardiovascular benefits. We showed, in this randomised pilot study, that the practice of yoga incorporated in a 3-month exercise training program was associated with significantly greater improvement in resting blood pressure (~3-4 mm Hg with stretching vs ~8-11 mm Hg with yoga; $P < 0.001$) and heart rate (~4 beats/min with stretching vs ~5 beats/min with yoga; $P < 0.001$) and Reynolds Risk Score (~6% with stretching vs ~14% with yoga; $P < 0.001$) compared with the control stretching group. Risk-prediction models that incorporate hs-CRP, such as the Reynolds Risk Score, have been developed to improve risk classification and the accuracy for global risk prediction, particularly for patients considered to be "intermediate risk" by algorithms such as the Framingham Risk Score.[12] These findings suggest that yoga may hold promise as an add-on lifestyle intervention that can be incorporated into cardiovascular disease prevention strategies in replacement of routine stretching exercises. There is large variation in existing yoga practices, particularly modern postural yoga practices. This variability makes it difficult both to report the prescription and dose of yoga and for researchers to evaluate the effects of yoga, because interventions are often poorly described and reported. Here, the yoga routine was well described and well structured, including different components of yoga of the same time duration (15 minutes) as the stretching component in the control group. The sport and exercise medicine scientific community are currently inconsistent and ambiguous in their inclusion of yoga as a form of exercise and physical activity for health-related outcomes.[2] Here, we provide randomised data using a novel and emerging modality that has the potential to improve cardiometabolic health outcomes in the settings of cardiometabolic rehabilitation.

Our findings are consistent with a systematic review that reported an average reduction in systolic blood pressure of 7.9 mm Hg and diastolic blood pressure of 4.3 mm Hg among participants following a yoga intervention.[5] However, given that yoga is a complex activity, it might be unwise to tackle a single mechanism explaining the antihypertensive effects of yoga. There are several possible underlying mechanisms explaining the positive effects of yoga on blood pressure.[13,14] One of the hypothesised mechanisms is that yoga positively affects the autonomic nervous system by stimulating parasympathetic concomitantly to reducing activity of sympathetic nervous system activity, which could translate into reduced resting heart rate as found in our study.[14] Yoga may also increase bioavailability and blood levels of nitric oxide, promoting vasodilation.[14] A decrement in cortisol level, a stress hormone that has been linked to high blood pressure, could also be implicated in the positive pathophysiologic response of yoga on blood pressure.[15]

Regarding the changes of lipid profile comparing yoga with usual care, it was reported from a meta-analysis and pooled results that yoga generated significant reduction of TG level and increase of HDL-C level but had no effect on LDL-C or total cholesterol.[16] We found a decrease in LDL-C levels and TG. However, this decrease was observed in both group, supporting that the yoga intervention *per see* was not associated with an additive impact on LDL-C level and TG in light of the exercise training regimen. Low-grade inflammatory marker levels, such as hs-CRP, predict cardiovascular outcomes.[17] It was shown that a 12-week yoga-based lifestyle intervention lowered the levels of adipokines, inflammatory mediators, and oxidative stress.[18] Our 3-month exercise program was associated with significantly greater improvement in the Reynolds Risk Score in the yoga group, whereas the Framingham Risk Score decreased similarly in both groups (Table 2).

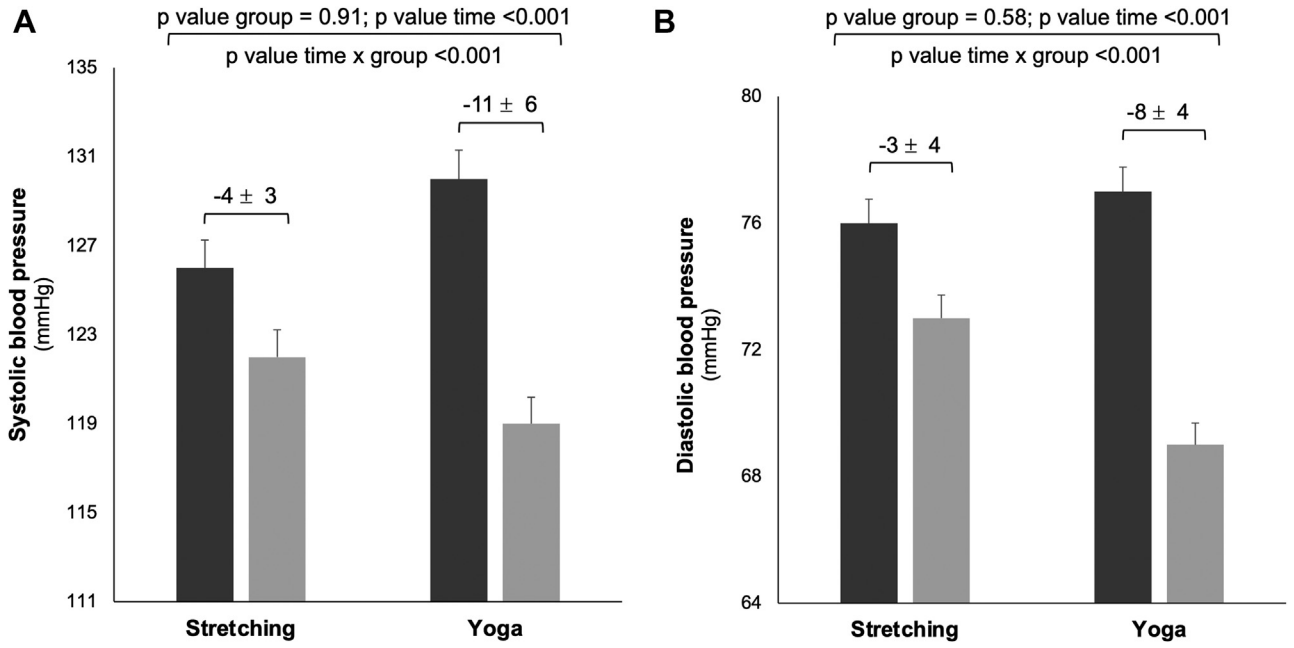

Figure 1. Changes comparison of (**A**) systolic and (**B**) diastolic blood pressure between yoga and stretching group. **Dark grey**: before intervention; **light grey**: after intervention.

Because exercise is associated with reduced risks of coronary events and mortality,[19-21] yoga might be a promising additive tool for patients at risk for cardiovascular disease because it is associated with improved quality of life, fewer composite cardiovascular events, and improved cardiovascular risk factors.[16] Furthermore, exercise-based cardiac rehabilitation programs are an effective strategy for secondary prevention for cardiovascular disease,[22-24] as supported by the highest possible recommendation (1A) in guidelines.[25] Cardiac rehabilitation is a complex intervention involving multidisciplinary teams to deliver exercise training, stress management, psychosocial support, and secondary prevention. Safety and benefits considered, yoga is a promising alternative and complementary choice for exercise-based cardiac rehabilitation. Yoga therapy is beneficial in maintaining global health by regulating cardiovascular risk factor. The efficacy of yoga therapy on blood pressure and Reynolds Risk Score in our study may have direct impact on its use as a safe therapeutic modality in managing cardiometabolic diseases.

Table 2. Comparison between stretching and yoga on body mass index, blood pressure, lipid profile, blood glucose, inflammation, and Reynolds Risk Score

	Stretching (n = 30)		Yoga (n = 30)				
	Before intervention	After intervention	Before intervention	After intervention	*P* value, group	*P* value, time	*P* value, time × group
Body mass index, kg/m^2	31.7 ± 3.3	31.4 ± 2.6	32.4 ± 3.1	32.0 ± 2.5	0.37	0.09	0.92
Systolic blood pressure, mm Hg	126 ± 11	122 ± 11	130 ± 13	119 ± 11	0.92	< 0.001	< 0.001
Diastolic blood pressure, mm Hg	76 ± 7	73 ± 8	77 ± 10	69 ± 8	0.58	< 0.001	< 0.001
Heart rate, beats/min	74 ± 11	71 ± 10	73 ± 11	66 ± 11	0.24	< 0.001	0.002
Pulse pressure, mm Hg	50± 10	50 ± 11	52 ± 9	50 ± 7	0.71	0.001	0.03
Mean arterial pressure, mm Hg	93 ± 7	89 ± 8	95 ± 10	86 ± 9	0.69	< 0.001	< 0.001
HDL cholesterol, mmol/L	1.26 ± 0.55	1.29 ± 0.48	1.18 ± 0.31	1.30 ± 0.36	0.76	0.52	0.29
LDL cholesterol, mmol/L	3.11 ± 0.42	2.68 ± 0.38	3.19 ± 0.50	2.72 ± 0.46	0.60	< 0.001	0.45
Triglycerides, mmol/L	2.32 ± 0.39	1.92 ± 0.27	2.46 ± 0.43	1.92 ± 0.37	0.40	< 0.001	0.10
Fasting blood glucose, mmol/L	5.4 ± 0.4	5.0 ± 0.3	5.6 ± 0.6	5.2 ± 0.4	0.10	< 0.001	0.77
HbA_{1c}, %	5.5 ± 0.3	5.2 ± 0.2	5.7 ± 0.4	5.3 ± 0.4	0.04	< 0.001	0.16
hs-CRP, nmol/L	2.3 ± 0.4	1.8 ± 0.6	3.0 ± 0.9	2.1 ± 0.6	< 0.001	< 0.001	0.12
Reynolds Risk Score	9.0 ± 2.0	8.4 ± 2.0	8.2 ± 1.7	7.0 ± 1.3	0.01	< 0.001	0.03
Framingham Risk Score	14.8 ± 9.1	12.5 ± 7.7	15.0 ± 8.6	11.2 ± 8.5	0.80	< 0.001	0.13

HbA_{1c}, glycated hemoglobin; HDL, high-density lipoprotein; hs-CRP, high-sensitivity C-reactive protein; LDL, low-density lipoprotein.

However, more research is needed before yoga should be added to cardiac rehabilitation guidelines. **Yoga**-based **Ca**rdiac **Re**habilitation (Yoga-CaRe), a randomised controlled trial, found that a yoga-based cardiac rehabilitation program was safe and effective in improving quality of life and return to preinfarct activities after acute myocardial infarction[26] after a median follow-up of 21.6 months. However, that study was underpowered (43% study power based on original assumptions) for the composite outcome (composite of death from any cause, nonfatal myocardial infarction, nonfatal stroke, or emergency cardiovascular hospitalisation) owing to a lower than anticipated event rate. The authors are planning follow-up of the trial participants for 2 more years to provide more definitive evidence regarding the yoga intervention. Nevertheless, yoga is increasingly being considered a viable integrative treatment option for health and wellness. However, it remains unclear whether the scientific community considers yoga to be a form of physical activity and would include it as a recommended form of exercise to improve health-related outcomes in replacement of stretching.[2] Nonetheless, we provide support that yoga should be considered an important component of an exercise training regimen program, given its potential for further blood pressure reduction, and improved lipid profiles, systemic inflammation as measured by hs-CRP, and calculated Reynolds Risk score.

Study limitations

This study has some limitations. Hypertension was diagnosed based on blood pressure measurements on office blood pressure readings and defined as $\geq$ 140/90 mm Hg for 3 measurements on different days as per 2020 Canadian Hypertension guidelines.[9] Although most participants were previously diagnosed as hypertensive by their health care providers, it might be that we misclassified some of the newly diagnosed participants. Yet we reported a higher decrease in blood pressure in our participants with a yoga intervention. We did not perform a sample size calculation but rather used a convenience sample of participants to be included. When estimating the sample size for a pilot trial, a general flat rule is to use at least 30 subjects to estimate a parameter,[27] whereas Julious suggests a minimum sample size of 12 subjects per treatment arm.[28] Others recommend pilot trial samples sizes of 75, 25, 15, and 10 to reduce the imprecision around the estimate of the standard deviation.[29] The Consolidated Standards of Reporting Trials Group and bodies such as the National Institute for Health Research and the National Research Ethics Service state that not all studies necessarily need a power-based sample size calculation but that they do all need a sample size justification. With this in mind, we included a number of participants similar to other studies involving yoga intervention in patients with hypertension.[5] Therefore, we are confident that our pilot study is valid. Age-predicted target heart rate (220 minus age) was used as a measure of intensity regarding the aerobic portion of the exercise training regimen. This is the most commonly used age-predicted maximal heart rate proposed by Fox et al. in 1971.[30] Several equations were compared recently (Fox, Gellish, Gulati, Tanaka, Arena, Astrand, Nes, Fairbarn) and the results showed poor agreement between measured maximal heart rate and age-predicted maximal heart rate. It was concluded that the Fox equation may represent the best option for a general population because it is less likely to under- or overestimate based on individual maximal heart rate.[31] Unfortunately, the exercise capacity of the participants was not measured before and after the training regimen, because VO_{2max} is not assessed routinely in primary prevention program owing to lack of resources and/or funding. A strength of the present study is that the yoga routine was well described, was of the same time duration as the stretching component in the control group, and could be easily replicated.

Conclusion

The practice of yoga incorporated in a 3-month lifestyle intervention program was associated with a significantly greater improvement in blood pressure, heart rate, and the Reynolds Risk Score compared with the control stretching group.

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Disclosures

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Supplementary Material

To access the supplementary material accompanying this article, visit the online version of the *Canadian Journal of Cardiology* at www.onlinecjc.ca and at https://doi.org/10.1016/j.cjca.2022.09.019.