

# Yoga Offers Cardiovascular Protection in Early Postmenopausal Women

## Abstract

**Context:** Postmenopause, an estrogen deficient state comes with increased incidence of cardiovascular diseases (CVDs). *Yoga* has been described as having a beneficial effect on heart rate variability (HRV), a marker for cardiac autonomic activity which can assess cardiovascular risk, in various populations. **Aim:** the aim of the study was to study the effect of 3-month long *Yoga* practice on HRV in early postmenopausal women. **Settings and Design:** A prospective longitudinal study of 67 women within 5 years of menopause between 45 and 60 years of age attending menopause clinic of Department of Gynaecology, Sucheta Kriplani Hospital fulfilling inclusion and exclusion criteria and consenting were enrolled for the study. **Subjects and Methods:** HRV of 37 cases (*Yoga* group) and 30 controls (*non-Yoga* group) was recorded pre and 3-month postintervention. **Statistical Analysis Used:** GraphPad Prism Version 5 software was used. Values are a mean and standard error of mean. Statistical significance was set up at  $P < 0.05$ . **Results:** In HRV, frequency domain analysis showed a significant fall in low frequency (LF) in normalized units (nu) and LF: high frequency (HF) ratio and significant rise in HF in nu in the *Yoga* group (depicting parasympathetic dominance) against a significant rise in LF (nu) and LF: HF ratio and significant fall in HF (nu) in *non-Yoga* group (indicating sympathetic dominance). Time domain analysis showed a significant decrease in Standard Deviation of NN intervals in *Non-Yoga* group against nonsignificant changes in *Yoga* group indicating deterioration in parasympathetic activity in *non-Yoga* group. **Conclusions:** Three-month long *Yoga* practice improved HRV in early postmenopausal women significantly and has the potential to attenuate the CVD risk in postmenopausal women.

**Keywords:** *Cardiac autonomic activity, cardiovascular diseases, heart rate variability, high-frequency power, low frequency:high-frequency ratio, low-frequency power, Yoga*

## Introduction

Cardiovascular diseases (CVDs), especially coronary heart diseases (CHDs), are the leading cause of death in postmenopausal women<sup>[1-3]</sup> and will be responsible for an estimated 23.3 million deaths by 2030, with over 80% of those deaths occurring in low- and middle-income countries.<sup>[2,4]</sup>

Despite decades of dedicated research and large accumulated evidence, risk versus benefit profile of hormone replacement therapy (HRT) in postmenopausal women remains controversial. The Framingham Study,<sup>[5]</sup> Postmenopausal Estrogen/Progestin Intervention,<sup>[6]</sup> and the Nurses' Health Study<sup>[7]</sup> suggest a positive causal association between estrogen use and a reduced CVD risk, but World Health Initiative Trial,<sup>[8]</sup> Heart and Estrogen/Progestin Replacement Study,<sup>[9]</sup> the Estrogen Replacement for Atherosclerosis,<sup>[10]</sup> and a trial of HRT in women with unstable angina which did not

record a reduction in ischemic events,<sup>[11]</sup> report otherwise.

Heart rate variability (HRV) analysis is an established, simple to perform, noninvasive, and sensitive research tool to evaluate the autonomic modulation of heart activity in health as well as disease.<sup>[12]</sup> Menopause has been associated with an unfavorable HRV profile in a score of studies.<sup>[13-16]</sup>

*Yoga* is an ancient Indian holistic art of living meant to quieten the mind and achieve its union with the divine intelligence of the universe.<sup>[17]</sup> Defined by Sage *Patanjali* as "Yogah chitta vritti nirodhah" and Sage *Vasishtha* as "manah prashamana upayah yogah," *Yoga* offers *asanas*, *kriyas*, *mudras*, *bandhas*, and conscious physical relaxation for the body; concentration and meditation for the mind and *Pranayama* techniques to absorb "prana," the life energy of the universe for the sustenance of the being (*Chandogya Upanishad*).<sup>[18,19]</sup>

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Systematic reviews by Kim E Innes *et al.*<sup>[20]</sup> and Holger Cramer *et al.*<sup>[21]</sup> find *Yoga* to be effective in improving modifiable CVD risk factors in postmenopausal women. As the world postmenopausal women's population rises, there is a pressing need for a safe and effective intervention which can decrease the CVD morbidity and mortality without the adverse effects of HRT. We propose to study the influence of *Yoga* on HRV in early postmenopausal women, a much less chartered territory in the vast field of postmenopausal research.

## Subjects and Methods

### Study design

Prospective interventional study was carried out in the Departments of Physiology, Biochemistry and Obstetrics and Gynaecology in Lady Hardinge Medical College (LHMC) and Associated Hospitals, New Delhi.

### Participants

Sixty-seven women within 5 years of menopause between 45 and 60 years of age attending menopause clinic of Department of Gynaecology, Sucheta Kriplani Hospital were participants.

Inclusion criteria for the participants were (1) diagnosis of menopause by a gynecologist according to STRAWS<sup>[22]</sup> study criteria and menopausal for up to 5 years, (2) age group of 40–60 years, and (3) body mass index (BMI) <30.<sup>[23]</sup> Excluded participants were (1) patients with past or present history of hypertension, diabetes, coronary artery disease, or any other any known systemic illness; (2) on drugs that influence HRV as antihypertensives, antianginals, antipsychotics, or antidepressants or on HRT; or (3) already practising yoga or any known regular exercise regime.

No financial benefit or any other form of compensation was offered to the participants as cost of participating in the program. After confirming qualification and explaining the objective and design of the study, voluntary and informed signed consent of participants was obtained. Participants were divided into two groups on the basis of their willingness to join *Yoga*: control group ( $n = 30$ ) - postmenopausal patients receiving routine management and case group ( $n = 37$ ) - postmenopausal patients receiving routine management along with *Yogic* intervention.

### Measurements

Major physiological parameters including anthropometric measurements<sup>[23]</sup> were measured, and a semi-structured pro forma was filled. Participants were instructed to come after a light breakfast and to abstain from tea, coffee, or nicotine for at least 24 h before the recording to avoid known influences of these factors on autonomic state.<sup>[24]</sup> They were made accustomed with the laboratory settings and briefed about the procedure and apparatus to be used.

### Heart rate variability

HRV which is a quantitative marker of autonomic activity and developed by people drawn from the field of mathematics, engineering, physiology, and clinical medicine is a software which automatically collects and modifies the continuous electrocardiogram (ECG) recorded from three limbs - right arm, right foot, and left arm and eliminates from it the QRS complexes produced due to ectopic beats, arrhythmic events, missing data, and noise effects. We are thus provided with a record of adjacent QRS complexes produced due to pure sinus node depolarizations (the R-R interval so derived being called N-N interval) which is under the regulation of the autonomic nervous system (ANS) of body, independent of other factors affecting cardiovascular health.<sup>[12]</sup> HRV record so obtained is evaluated for the distribution of N-N intervals from the perspective of time and frequency. Time domain measures used for analysis were Standard Deviation of NN interval (SDNN) and Square root of the mean squared differences of successive NN intervals (RMSSD). For spectral density analysis (frequency domain analysis), the HRV power spectrum computed from the fast Fourier transform analysis on the filtered RR interval data was utilized. The energy in (1) very low frequency bands (VLF; 0.0033–0.04 Hz), (2) low frequency bands (LF; 0.04–0.15 Hz), (3) high frequency bands (HF; 0.15–0.4 Hz), and (4) LF: HF ratio was studied in both absolute powers ( $\text{ms}^2$ ) and normalized units (nu).

After 15 min of supine rest in quiet room at 25°C, ECG electrodes were placed on right arm, left arm, and right foot of Participant. Five minutes segment basal readings of HRV were recorded by autonomic neuropathy analyzer supplied by Recorders and Medicare Systems (RMS), Chandigarh, India. The data were stored in a PC and analyzed using software program developed by the R&D of RMS.

### Intervention

The participants in *Yoga* group received intervention in the form of integrated *Yoga* module comprising *asanas*, *pranayama*, *savasana*, and *OM* chanting given by trained *Yoga* instructors from LHMC. At a convenient time between 8 am and 1 pm, and after a minimum of 2 h of fasting, they were meticulously taught the uniform Yogic schedule exclusively designed for postmenopausal women based on the concepts from *Patanjali's yoga sutras* designed by AYUSH Department, LHMC for a minimum of 7 days. After having been made familiar with the program which was introduced in a phased manner and standardized for all [Table 1], they were instructed to practice it regularly at their house for 1 h every day for at least 6 days in a week for a total duration of 12 weeks. Those suffering from arthritis or having undergone knee replacement surgery were advised to perform yoga maneuvers while sitting on the chairs. Control group continued for 3 months with routine management without *Yogic* intervention.

The HRV was recorded in both groups at beginning and after 3 months of the study period [Figure 1].

**Outcome measurement**

An increase in sympathetic activity if observed in a HRV record indicates an increase in CVD risk by increasing heart rate and causing vasoconstriction of coronary blood vessels against a decrease in CVD risk if the parasympathetic activity increases in HRV recording by causing opposite changes.

**Ethics**

The approval of the Institutional Ethics Committee for Human Research was sought and obtained for the entire experimental protocol.

**Statistical analysis**

The data were subjected to statistical evaluation using GraphPad Prism Version 5 software. After testing for normality of distribution of data with the Kolmogorov–Smirnov goodness-of-fit test, data were presented as mean values ± standard error of mean. Intergroup comparison between Group 1 and Group 2 for parametric data was done using unpaired “t” test and for nonparametric data were done using Mann–Whitney U-test. Intragroup analysis after intervention was done using paired t-test for normally distributed and Wilcoxon matched pair test for nonparametric data. Statistical significance was set up at  $P < 0.05$ .

**Results**

The study did not register any dropout due to dedicated motivation by the authors and the Yoga Department.

**Table 1: The yogic schedule**

<b>Asanas (30 min)</b>	
Standing series (3)	<i>Katichakrasana</i> <i>Tadasana</i> <i>Ardha kati chakrasana</i>
Supine series (3)	<i>Uttanapadasana</i> (30, 45, 90) <i>Pavanamuktasana</i> <i>Setubandhasana</i>
Prone series (2)	<i>Bhujangasana</i> <i>Shalabhasana</i>
Sitting series (4)	<i>Gomukhasana</i> <i>Yogamudra</i> <i>Ushtrasana</i> <i>Pashcimottanasana</i>
<b>Pranayama (30 min)</b>	
<i>Kapalbhati</i> - 3 min	<i>Anulom vilom</i> - 7 min
<i>Bhramari</i> - 24 rounds - 5 min	<i>AUM</i> chanting - 24 rounds over <i>agyachakra</i> (eyebrow centre) (8 min)
<i>Shavasana</i> with deep relaxation technique-7 min	

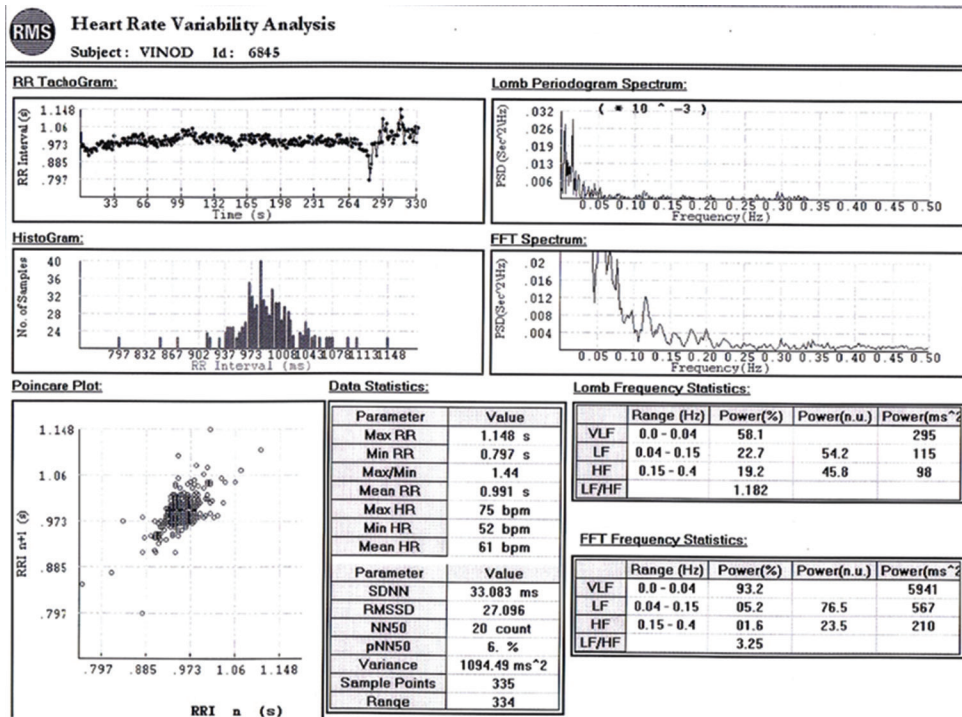


Figure 1: Heart rate variability records of a participant from Yoga group. LF = Low frequency band, HF = High frequency band, LF (nu) = Low frequency in normalized units, HF (nu) = High frequency in normalized units, LF (nu)/HF (nu) = Low frequency (normalized units):high frequency (normalized units), RMSSD = Square root of the mean squared differences of successive NN interval, SDNN = Standard Deviation of NN intervals

Table 2 depicts no significant difference in age, duration of menopause, height, neck circumference, waist circumference, hip circumference, and body fat percentage between the two groups. However, weight, BMI and diastolic blood pressure of the two groups are significantly different making them noncomparable. Hence, we decided to undertake intragroup study pre- and post-intervention as the chosen method of analysis.

Table 3 depicts LF (nu), which reflects sympathetic activity of ANS, showing a significant rise in *Non-Yoga* group and a significant fall in *Yoga* group. HF (nu) indicative of parasympathetic activity shows a significant fall in *Non-Yoga* group but a significant rise in *Yoga* group.

**Table 2: Baseline physiological parameters of control group and case group**

Parameters	Control group (n=30)	Case group (n=37)	P
Age (years)	52.97±0.72	51.78±0.82	NS
Duration of menopause (years)	3.43±0.23	3.02±0.23	NS
Weight (kg)	60.58±2.31	66.52±1.50	0.0294*
Height (m)	1.54±0.09	1.545±0.01	NS
BMI (kg/m <sup>2</sup> )	25.34±0.82	27.88±0.62	0.0294*
Neck circumference (cm)	33.03±0.44	33.03±0.35	NS
Waist circumference (cm)	93.83±2.23	95±2.68	NS
Hip circumference (cm)	102.1±2.21	104.8±1.34	NS
Body fat (%)	42.03±1.76	43.83±1.43	NS
Resting heart rate (beats/min)	77.47±3.41	74.46±2.04	NS
Respiratory rate (breaths/min)	14.2±0.244	13.95±0.26	NS
Systolic BP (mmHg)	125.2±2.08	127.2±1.28	NS
Diastolic BP (mmHg)	80.77±1.41	84.72±0.74	0.0114*

P>0.05 = Non-significant, \*P<0.05 (Significant), \*\*P<0.01 (Very significant),\*\*\*P<0.001 = Highly significant.<sup>[25]</sup> NS = Nonsignificant, BMI = Body mass index, BP = Blood pressure

Consequent to these effects, LF: HF ratio denoting an overall sympathovagal balance shows a significant rise in *Non-Yoga* group but a significant fall in *Yoga* group depicting favorable shift to parasympathetic dominance on the heart of *Yoga* practitioners.

Absolute powers of frequency domain analysis of HRV depict overall robustness of autonomic discharge rate. *Yoga* group shows a significant rise in HF (ms<sup>2</sup>), LF (ms<sup>2</sup>), VLF (ms<sup>2</sup>), and total power (ms<sup>2</sup>) whereas no such trend is seen in the *Non-Yoga* group.

RMSSD and SDNN parameters show a rise in *Yoga* group which fails to achieve statistical significance. However, the *Non-Yoga* group has shown a nonsignificant fall in RMSSD, and a significant fall in SDNN parameters denoting worsening of parasympathetic influence over their hearts after 3 months of the study period.

### Discussion

The link between *Yoga* and HRV in early postmenopausal women was the starting point and primary goal of this research endeavor. Previous studies have suggested positive influences of *Yogic* practices on cardiac autonomic activity (CAA) in various populations as measured by HRV. Our data demonstrate a substantial and significant improvement in HRV in early postmenopausal women with 3 months of *Yoga* intervention which may pave the way for clinically important implications of CHD risk in them.

In frequency domain analysis of HRV, the *Yoga* group showed a significant improvement from resting baseline values after 3 months of continuous *Yoga* practice. The significant rise in HF (nu) coupled with a significant decrease in LF (nu) and LF: HF ratio is suggestive of a shift of CAA toward beneficial vagal dominance in our participants. The significant increase in absolute powers of all frequency domain parameters suggests an increased

**Table 3: Low frequency (nu), high frequency (nu), low frequency:high frequency ratio, high frequency (ms<sup>2</sup>), low frequency (ms<sup>2</sup>), very low frequency (ms<sup>2</sup>), total power (ms<sup>2</sup>), square root of the mean squared differences of successive NN interval and standard deviation of NN interval of control group and case group pre- and post-intervention**

Parameters	Control group (non-Yoga) (n=30)			Case group (Yoga) (n=37)		
	0 week	3 months	P	0 week	3 months	P
LF (nu)	68.05±1.84	74.29±1.96	0.023*	75.06±1.45	59.53±2.79	<0.0001***
HF (nu)	31.55±1.80	25.62±1.97	0.0019*	24.98±1.44	39.9±2.53	<0.0001***
LF:HF ratio	2.51±0.21	3.32±0.21	0.0021**	3.37±0.21	1.92±0.193	<0.0001***
HF (ms <sup>2</sup> )	378.3±30.90	358.6±26.79	NS	372.5±31.04	464.3±25.28	0.0038**
LF (ms <sup>2</sup> )	540.5±53.62	541.6±42.25	NS	723.1±38.32	847.2±39.75	0.0001***
VLF (ms <sup>2</sup> )	2829±272.3	2812±281.3	NS	3266±292.5	3541±314.8	<0.0001***
Total power (ms <sup>2</sup> )	3748±256.9	3712±267.8	NS	4362±294.0	4853±315.3	<0.0001***
RMSSD	23.86±2.12	20.57±1.36	NS	27.88±1.75	30.16±1.95	NS
SDNN	33.10±2.25	27.93±1.95	0.0062**	35.22±2.33	35.41±2.25	NS

P>0.05 - NS, \*<0.05 - significant, \*\*<0.01 - very significant, <0.001 - highly significant, \*\*\*<0.0001 - highly significant. LF = Low frequency, HF = High frequency, VLF = Very low frequency, SDNN = Standard deviation of NN interval, RMSSD = Square root of the mean squared differences of successive NN interval, NS = Nonsignificant

robustness of autonomic nervous activity after practicing *Yoga*. The *Non-Yoga* group recorded worsening of HRV in the form of a significant increase in LF (nu) and LF: HF ratio and a significant decrease in HF (nu). Absolute powers of frequency domain parameters showed a nonsignificant decreasing trend over this period.

Time domain parameters of HRV, i.e., RMSSD and SDNN reflect effect of HF power, i.e., parasympathetic variability on heart rate.<sup>[12]</sup> *Non-Yoga* group recorded a significant reduction in SDNN which is nonbeneficial for heart. *Yoga* group showed a beneficial trend toward rise in RMSSD and SDNN, but it failed to achieve statistical significance. A larger sample size and longer duration of study might have shifted the results toward significance for these parameters.

Overall, HRV results document a decrease in sympathetic tone and increase in parasympathetic dominance on CAA of participants in *Yoga* group against a definitive rise in sympathetic activity and fall in parasympathetic tone in our participants when followed up without practising *Yoga*.

Our study is partly in concordance with prior studies by Markil *et al.*,<sup>[26]</sup> An *et al.*,<sup>[27]</sup> and Telles *et al.*<sup>[28]</sup> However, all these studies were of shorter duration than ours, some employed a lesser number of patients, and some were without controls,<sup>[25,27]</sup> making our methodology more rigorous. Papp *et al.*<sup>[29]</sup> have demonstrated conflicting effect of *Yoga* on HRV in participants. A very low sample size and shorter duration of study could explain their findings. All these studies being done on younger population. Our study on early postmenopausal women which has not been undertaken till date, to the best of our knowledge, makes it much novel.

Past researches on *Yoga* can throw light on our observations. In the *Yogic* tradition, voluntary slow control of breathing has long been used to foster self-awareness and reduce unnecessary autonomic reactivity, due to the known reciprocal relation between breath and visceral and mental functioning.<sup>[30]</sup> Mindfulness developed by meditation has been associated with left-sided anterior activation, a pattern associated with positive effect on mind;<sup>[31]</sup> diminished amygdala response to emotional stimulus;<sup>[32]</sup> increased brain connectivity;<sup>[32]</sup> greater gray matter density in right anterior insula (involved in interoceptive awareness), left inferior temporal gyrus, right hippocampus, and right orbitofrontal cortex<sup>[34,35]</sup> as well as larger gyration in left precentral and right fusiform gyri and insula.<sup>[36]</sup> These studies overlap with regions of central autonomic network related to HRV.<sup>[37,38]</sup> HRV basically reflects the capacity of the central autonomic network comprising the prefrontal cortex, central nucleus of amygdala, hypothalamus, and brainstem to meet and adapt to environmental demands.<sup>[39]</sup> According to references by Swami Rama, the regulation of the respiratory rhythm is the most vital step in controlling the vagus nerve, thus permitting control of ANS.<sup>[40,41]</sup> Stressors

activate the hypothalamic–pituitary–adrenal axis releasing corticotropin-releasing hormone, adrenocorticotropic hormone, cortisol, and noradrenaline which can change the functioning of most of the body-regulating mechanisms, making this pathway a possible one affected by stress-control influences of *Yoga*.<sup>[42]</sup> General systemic psychophysical relaxation though a placebo effect too could play a role in the beneficial effects observed in *Yoga* practitioners.<sup>[20]</sup> Depletion of cardioprotective estrogen hormone after menopause is one among many other factors affecting cardiovascular regulation such as ANS, age, atherosclerosis, psychosomatic factors, and hypothalamic reactivity to stressors and not the only factor affecting CVD morbidity and mortality in postmenopausal women.<sup>[5]</sup> Improvement in HRV in postmenopausal women in our study consequent to *Yogic* practice, which indicates a decrease in CVD risk can well be attributed to reversal of deranged CAA by acting on these multiple factors, thereby leading to amelioration of the effects of menopause-induced estrogen deficiency, which is an irreversible change.

As a safe, natural, nonpharmacological technique with low implementation cost, ease of adoption by a broad range of population, high perceived satisfaction quotient, psychological benefits, and good compliance, *Yoga* supported by growing body of research-based evidence promises to be helpful in mitigating the acute as well as long-term sequel of climacteric, especially CVD.

## Conclusions

The present study on postmenopausal women within 5 years of menopause demonstrates a significant improvement in CAA at molecular level with parasympathetic dominance, as depicted by HRV, within a regular and sustained practice of *Yoga* for 3 months. However, the required duration of *Yoga* practice needed to reduce CVD risk in postmenopausal women is difficult to comment after a 3-month study and is beyond the scope of present research. To obtain such data, a randomized controlled study of much longer duration undertaking regular practice of *Yoga* followed by a diagnostic assessment of the cardiovascular status of the participants is highly recommended. If proved with scientific-based evidence, *Yoga* can be an effective strategy to attenuate the cardiac autonomic dysfunction induced by hormonal imbalances setting up in early postmenopause, giving us an opportunity for early intervention before the onset of full-blown CVD. Our study creates interesting avenues for researchers to take up the cause of postmenopausal health and substantiates the already growing evidence for the effectiveness of *Yoga* in preventing and ameliorating the health adversities faced by postmenopausal women worldwide.

## Limitations of the study

A small sample size, short duration of the study, and domiciliary practice of *Yoga* can count for limitations of

our study. While checking for home compliance with the assigned practice, verbal reports had to be relied upon.

### Future directions

Properly blinded and randomized controlled trials are difficult to run in *Yogic* research but necessary to confirm the results of our within-subject trials. There is need to apply rigorous, methodologically accurate research to study its effect on this population so that rational consensus and coherent paradigms are within our reach to maximize human benefit. Trials of this *Yoga* module in different cultures would explore generalizability and reproducibility of its effect on postmenopausal women worldwide. Additional studies to investigate its long-term effects on CAA and feasibility in prevention and therapeutics of cardiac rehabilitation too are called for.

### Strength of the study

The study was conducted on women in early stages of their menopause, which is a sparsely explored research area.

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### Conflicts of interest

There are no conflicts of interest.

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