How does meditation relate to quality of life, positive lifestyle habits and carbon footprint ?

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Keywords: meditation, mindfulness, carbon footprint, greenhouse gas, pro-environmental behaviour.

Abstract

Meditation has gained the scientific community's wide attention, which investigates behavioural modifications under the promotion of pro-environmentalism. The present research investigates relationships between *Vipassana* meditation experience (i.e. range of years of practice of continuous meditation preceding to the date of recruitment (RYP), average time duration of a regular meditation session (AtMS), trait mindfulness), positive lifestyle habits (PLH), quality of life (QoL) and per-head carbon footprint (CF) among 25 skilled meditators. Self-reported validated questionnaires were given to a group of native speakers of Sri Lanka to collect data on meditation experience, PLH, and perceived QoL. To collect data on CF, a booklet addressing the following four domains of CF was used: (i) CF associated with food and beverage consumption (CF_{FB}), (ii)CF associated with electricity consumption at residence (CF_{EC}), (iii) CF associated with travelling behaviour; (CF_{TB}) and (iv) CF associated with solid waste disposal behaviour at residence; CF related to disposal at the landfill site (CF_{SWDS}), open burning of solid waste (CF_{OB}). Correlation analyses revealed that trait mindfulness showed strong associations ($r > 0.4$) with PLH. None of the temporal variables of meditation experience was significantly correlated with any domain of CF. Two facets of mindfulness (observing and non-reactivity to present-moment experience) demonstrated statistically strong associations ($p < 0.05$) with perceived QoL. It was identified that the PLH significantly mediates the relationship between the observing facet of trait mindfulness and CF_{FB} (indirect effect -0.002, SE = 0.001 95% CI [0.010, 0.417]). Further, the relationship between acting with awareness and CF_{SWDS} was significantly mediated by the PLH (indirect effect – (-0.003), SE = 0.003 95% CI [-0.012, -0.0001]). The current study will serve as a foundation for future longitudinal studies on the same subject by providing evidence for the relationships between meditation experience and PLH, perceived QoL and CF.

1 Introduction

Meditation has been practised around the world for thousands of years under several religions and philosophies. Research has demonstrated a significant impact of it on psychological and physiological parameters. It lays the foundation for understanding the most fundamental concepts of life and reality by tapping into one's mind and behaviour (Kabat-Zinn, 2003)., In the current study, meditation refers to a set of mental practices which ultimately lead to insights into understanding the nature of one's mind. According to Buddhist literature, two major meditation techniques can be introduced: *Samatha* (concentrative meditation) and *Vipasssana*. The Pali term "*Vipassana*" generally means "seeing into something with clarity and precision, recognizing each component as separate, and penetrating all the way through to discern the most fundamental reality of that object" (Gunatratana, 2010). Since the past, meditation has been practised in various forms, including loving-kindness, body scanning, Zen meditation, mindfulness and breathing.

The most studied pertinent personality trait to date for meditation-based research may be mindfulness (Brown and Ryan, 2003). Kabat-Zin (2003) mentioned that mindfulness is a core concept of all streams of Buddhist meditation practice. The ability to pay attention to the current moment while retaining an open, nonjudgmental frame of mind is known as mindfulness (Brown and Ryan, 2003). Given that one of the main objectives of meditation is to encourage present-moment awareness and attention, the aforementioned definition of mindfulness may seem familiar to many readers. Moreover, Gunaratana (2010) mentioned that mindfulness can be practised during any activity related to *Vipassana* meditation.

The two main branches of mindfulness are state mindfulness and trait mindfulness/dispositional mindfulness (Eisenlohr-Moul, 2016). A state practised in meditation can be introduced as state mindfulness and it links with the trait mindfulness which is one's proclivity to be mindful in everyday life (Bravo et. al., 2018; Khoury et. Al., 2017). According to Hosemans (2015), trait mindfulness in long-term meditation practitioners is higher than in non-meditators. Further, it has been found that there was no significant difference in trait mindfulness between concentrative meditators and insight meditators. As mentioned by Bergomi et al. (2015), even if there was no difference in trait mindfulness levels among meditation practitioners in Zen, *Vipassana* and body movement techniques, a significant association between meditation practice and trait mindfulness could be found. The same finding for the relationship between meditation practice and trait mindfulness was found by Falkenström, (2010) through studying *Vipassana* meditators. These findings provide evidence to prove the hypotheses that the meditation technique is not a strong predictor of trait mindfulness and meditation improves trait mindfulness.

The examination of only a narrow range of factors associated with meditation practices, which may hamper the unambiguous identification of its helpful nature, is a significant drawback of meditation studies (Thomas and Cohen, 2014). Along with the trait mindfulness, as mentioned by Shapiro and Britton (2014), the temporal effects of meditation on aspects of studies should be considered. Length of meditation practice, length of a regular meditation session and frequency of meditation per day can be considered in this regard. Further, as variables of studying, considering person-related factors (eg. perceived quality of life (QoL) and impact of meditation on daily life) in relation to meditation practice is important.

Meditation is a recommended practice for everyone seeking a higher degree of QoL. By practising meditation regularly, a person creates internal space and clarity that allows them to manage their brain regardless of the circumstances (Bajpai and Kiran, 2020). According to WHO (2001), an

individual's perception of their status of life is introduced as perceived quality of life. Physical, psychological, environmental and socioeconomic status of a person could be investigated in assessing one's perceived QoL (Wong et al., 2018; Higuchi and Liyanage, 2019). Dassanayaka et al. (2022) mentioned that higher perceived QoL was found in skilled meditators (*Vipassana* meditators who have more than 3 years of continuous practice of meditation and who can maintain continuous attention on the meditation object) compared to age-gender-matched non-meditators. As mentioned by Dargah (2017), *Vipassana* meditation is associated with higher perceived quality of life.

Vipassana meditation teaches people to examine their sensory experiences, observe thoughts as they arise, and react with calm detachment and clarity, reducing compulsive reactivity and allowing them to behave more intentionally (Gunaratana 2010). Five mental hindrances (FMH; sensual desire, ill-will, sloth and torpor, remorse and sceptical doubt) are seen as unwholesome negative states that impede clearer vision and prevent man from acting effectively in daily life. Moreover, Abblett (2018) stated that meditation is the mirror that precisely displays how each of the hindrances is encasing our perspective on life. Therefore, meditation may play a role in promoting positive lifestyle habits (PLH) by inhibiting negative mental states. A positive lifestyle habit is a behaviour, deed, or attitude that a person desires to adopt and incorporate into his or her life because it has beneficial outcomes. According to Lea et al. (2014), PLH associates with well-being and good health. Meditation, as noted by Ee et al. (2022), may aid in boosting the beginning and maintenance of beneficial lifestyle practices. Sieja (2019) argued that PLH which supports the best performance of college students in academic work could be promoted through meditation. Even if there are studies on the impact of meditation on PLH related to the well-being and health of clinical populations, there is a lack of studies on the relationship between meditation experience and PLH in the daily lives of non-clinical long-term meditator groups which was the focus of the present research.

Only a handful of research could be found on the role of meditation in pro-environmental behaviours. As found by Jacob et. al. (2009), mindfulness meditation is positively associated with sustainable household choices and sustainable food practices. Researchers have found that pro-environmental behaviours such as eating lower Carbon food, using eco-friendly travelling methods, recycling, water-saving and mindful consumption of energy are common practices among meditators and mindfulness practitioners (Dharmesti et al. 2020; Grabow et al. 2018; Hunecke and Richter 2019; Panno et al. 2018). Panno et al. (2018) were able to find that the belief in climate change is significantly higher in Zen (mindfulness) meditation practitioners than in non-meditation practitioners. Even if Thiermann et al. (2020a) found that meditators who practice mindful compassion are more deeply motivated toward the environment and generate less negative environmental impact. Riordan et al. (2022) found that there is no significant difference in relation to ecological footprint between *Vipassana* long-term meditators and meditation naïve group. Further, Thriemann et al. (2020a) highlighted the importance of studying the meditation practice including the frequency of meditation in research on the role of meditation in pro-environmental behaviour. With its impact on particular linked factors such as environmental attitudes and perceived quality of life, meditation training has become an effective technique of boosting pro-environmental behavior (Barrett et al., 2016; Geiger et. al., 2019; Thiermann and Sheate, 2020b; Wamsler et al., 2021). Out of a handful of research on the role of meditation in pro-environmental behaviours, a limited number of scientific studies have focused on the role of meditation in controlling greenhouse gas (GHG) emissions. Moreover, research on studying the associations between GHG emissions and the meditation practice of long-term meditators is sparse.

Global anthropogenic GHG emissions have continued to increase since the industrial era and increased greenhouse gases (GHGs) have been the dominant cause of the observed global warming trend since the mid-20th century (IPCC, 2014a). The increasing GHGs in the troposphere cause long-term climate changes, bringing negative consequences in many parts of the world. Moreover,

transitioning to sustainable lifestyles has been implemented as a part of the efforts toward net-zero carbon societies. Transitioning to net-zero carbon societies with a higher quality of life might be facilitated through lifestyle innovations including meditation-based interventions. However, identifying meditation practice-associated predictors such as duration of meditation practice, time duration of a regular meditation session in the role of per-head GHG emission and having a better quality of life is still under exploration. Moreover, there is a lack of studies on the mediating mechanism of lifestyle factors such as perceived quality of life and lifestyle habits on the relationship between meditation experience and per-head carbon footprint (CF; GHG emission in carbon dioxide equivalent (CO2eq) per individual per year).

We follow the argument that meditation experience (study variables -. range of years of practice of continuous meditation preceding to the date of recruitment (RYP), average time duration of a regular meditation session (AtMS), trait mindfulness) may have associations with PLH, per head CF and perceived QoL. Hence the primary objective of the present study was to explore the possible correlations between meditation experience and PLH, per-head CF, perceived QoL. Based on the observed significant correlations in the present study and the findings of previous studies, the following argumentation was developed to investigate the mediating role of PLH in the relationship of meditation experience with per head CF as the secondary objective of the present study.

Out of all studied variables under the meditation experience, only the trait mindfulness significantly correlated with per-head CF. Similar findings on the relationship between pro-environmental behaviour and trait mindfulness were found by Brown and Kasser (2005), Amel et al. (2009), Jacob et al. (2009), Barbaro and Pickett (2015) Geiger et al. (2018), Panno et al. (2018) and Hanley et al. (2020). Awareness of the present moment causes us to have better self-awareness. Self-awareness empowers us to affect outcomes, makes us better decision-makers, and boosts our self-esteem (Chatzisarantis and Hagger, 2007; Kang et al., 2013). Moreover, Lee et al. (2022) argued that mindfulness has the potential to increase self-esteem and reduce stress, therefore cultivating positive attitudes about one's life. When one is positive, she or he thinks positively, feels positive, and exhibits positive actions like benevolence and compassion. Therefore, positive lifestyle habits can be expected with enhanced trait mindfulness through practicing meditation. As trait mindfulness is connected with both per head-CF and PLH, we assumed that PLH may play a mediating role in the relationship between trait mindfulness and per-head CF. Therefore, the hypotheses tested in the present study were as follow

Hypothesis 1: Relationship between the observing facet of mindfulness and per-head carbon footprint based on food and beverage consumption is mediated by positive lifestyle habits.

Hypothesis 2: Relationship between trait mindfulness and per-head carbon footprint based on travel behaviour is mediated by positive lifestyle habits.

Hypothesis 3: Relationship between the acting with awareness facet of mindfulness and per-head carbon footprint based on solid waste disposal behaviour is mediated by positive lifestyle habits.

2 Methodology

2.1 Study design

This study was a cross-sectional study which used purposive sampling technique to select study subjects. Correlational analysis and ordinary least square regression were conducted to identify possible associations and relationships between meditation experience and PLH, per head CF and perceived QoL.

2.2 Selection of study participants

The study participants (114 regular meditation practitioners) aged between 30 – 65 years and had regularly practised *Vipassana* meditation atleast for 4 hours per week for 3 years as the minimum duration of continuous practice of meditation preceding the date of recruitment were selected from meditation centres located in the districts of Colombo, Gampaha, Matale and Kandy in Sri Lanka. The selection of the study participants was assisted by a meditation Guru/trainer of the relevant meditation centre. Meditators who had physical disabilities, diabetes and those who followed a food-based dietary guideline were excluded.

All eligible participants (70 experienced meditators) were further screened using a structured screening test: the "The University of Colombo Intake Interview to identify Skilled Meditators for scientific research (UoC-IISM)" which was a judgmentally validated interviewer-administered questionnaire (Outschoorn et al., 2022). Based on the obtained scores for the sections of UOC-IISM (section C1: fall back score (FS) = 7-9 and ideal score (IS) = 10-12, section C2: FS = 14-16 and IS =17-20, section D: FS = 25–29 and IS = 30-35), skilled meditators were recruited for the current study. Skilled meditators can sustain an exclusive single point of attention together with vivid mindfulness (Outschoorn et al., 2022). It is considered that a skilled meditator can be aware of the state of mind at every moment.

2.3 Sample size

G*power (Faul et al., 2009) was considered in calculating sample size considering the F test category as suggested by Schoemann et al. (2017) for sample size calculation in mediation analysis. When the power and the effect size were set at 0.8 and 0.25 respectively under the statistical test for Linear multiple regression; fixed model, the sample size was 34 (for simple mediation analysis with three variables: X, Y and the mediator variable).

2.4 Characteristics of the study participants

The mean section scores of UOC-IISM and lifestyle characteristics of the study participants (n= 25, (1-β) = 0.66) are outlined in Table 1. The mean age ($\pm$SD) of the participants was 44 $\pm$ 10.39 years. Fifty-two percent of the study population was males. All the participants had completed secondary education. All the study participants were guided by a meditation Guru/trainer and 19 participants had practised meditation for more than 5 years. The percentage of meditators who practised meditation on daily basis was 81 %. Breath was the meditation object of 68 % of study participants while body parts were used as meditation objects by 52 % of participants. Further, 76 % of participants practised meditation through contemplating word phrases regarding promoting compassion and loving-kindness.

Table 1: Characteristics of the study group (n=25)

Mean scores of UOC-IISM		
	Mean (±SD) - Section C1	8.66 ± 1.05
	Mean (±SD) - Section C2	16.64 ± 2.62
	Mean (±SD) - Section D	29.07 ± 2.97
Lifestyle factors		
i.	Employment status (% of employees)	92 %
ii.	Marital status (% of participants under the status of currently married)	56 %
iii.	Average household monthly income (% of participants who had an average household monthly income more than Rs. 100,000)	48 %
iv.	Non-vegetarian (%)	92 %
v.	Awareness of per capita Carbon footprint (% of participants who had awareness of per capita Carbon footprint)	44 %
vi.	Awareness of global warming (% of participants who had awareness of global warming)	92 %
vii.	Perception on travelling status per day (% of participants who travelled a lot per day based on their opinion)	36 %
viii.	Possibility to use wood as fuel (% of participants who said that it is possible to use wood)	36 %

2.5 Assessment procedures

Questionnaire-based data collection methods were used in the present study. All the research procedures were tested for feasibility and details regarding each tool have been given in Annex 1.

2.5.1 Meditation experience

2.5.1.1 Temporal variables of meditation experience

Buddhist Meditation Experience Questionnaire, BMEQ (Somarathne et al., 2019) was used in collecting data on temporal variables of meditation practice (RYP, AtMS). The BMEQ was developed and judgmentally validated (i.e. face validity, content validity and consensual validity were ensured) by the same research group. The range of years of practice of continuous meditation preceding to the date of recruitment (RYP) was assessed using 1 to 4 scale ranging from less than one year of meditation practice to more than five years of meditation practice. A 1 - 3 scale ranging from less than 30 minutes of average time duration of a regular meditation session to more than 60 minutes of average time duration of a regular meditation session was used to assess AtMS..

2.5.1.2 Trait mindfulness

A judgmentally validated (i.e. face validity, content validity and consensual validity were ensured) *Sinhala* (i.e. native language) version of the FFMQ which is a 39-item psychological questionnaire

was used to explore meditators' trait mindfulness. The original version, the English version of FFMQ was developed by Baer et al. (2006) and it addresses five elements of trait mindfulness: i. non-reactivity to present moment experiences, ii. observing/ attending to sensations/perceptions/thoughts/feelings on the recent moment, iii. acting with awareness /concentration, iv. describing/labelling experience with words and v. non-judging of experience. A 5-point Likert scale ranging from 1 (never or very rarely true) to 5 (very often or always true) was used in rating items.

The scientific validation of the *Sinhala* version of FFMQ was carried out by Outschoorn et al. (2021) and the Cronbach's alpha level for the overall scale is 0.91. Moreover, acceptable Cronbach's alpha levels (α ranges from 0.77 to 0.92) for the five subscales indicate good internal reliability of the scale. Baminiwatta et al. 2022 who conducted research in a Sri Lankan Buddhist context reported a range of Cronbach's alpha from 0.67 to 0.72 as internal consistency of 5 subscales of a Sinhala version of FFMQ. However, only 21% of the study sample consisted of regular meditation practitioners and the importance of ensuring the validity of a Sinhala version of FFMQ among regular practitioners of meditation has been emphasized.

2.5.2 Per-head CF

Data collection sheets were prepared using the guidelines for GHG emission inventorying and calculation (IPCC, 2006; WBCSD/WRI, 2004) . A participant had to record data for 14 days. A request was made to avoid days when the participant can not follow the usual daily routine. Data collection sheets were bound into a booklet for use in collecting GHG emission data under 4 domains: (i) food and beverage consumption, (ii) electricity consumption at residence, (iii) traveling and (iv) solid waste disposal at residence. All the guidelines for recording data were provided in writing and verbally and data recording was followed up every 3 days during the experimental period. Collected data was used in calculating carbon footprints under the aforementioned domains.

(i) GHG emissions under food and beverage consumption

Participants recorded food and beverage consumption data under commonly used 7 measurement units (coconut shell spoon, tablespoon, teaspoon, number of teacups, number of water glasses, number of pieces of the food, whole food) in Sri Lanka and spaces were given if food and/or beverage consumption could be mentioned using metric units (kg/g/ml/l). Converting data into grams was assisted by weight conversion factors drawn from Jayawardena and Herath (2017) , Nette et al. (2016), Nutrition Division Ministry of Health (Ministry of Health, 2011) and Rahman et al. (2017). Emission factors for 43 food and beverage items were drawn from Carlsson-Kanyama and González (2009), Audsley et al. (2009), Clune et al. (2017), Elapata and De Silva (2018), Munasinghe et al. (2017), Nette et al. 2016) and Pathak et al. (2010) to be used in Equation 1. Total GHG emission (considering GHGs; CO_2, CH_4, N_2O) due to food and beverage consumption during the study in Carbon dioxide equivalent (i.e. CF) was calculated using Equation 1.

$$CF(FB) \times \left(\frac{14}{365} \times 10(-6)\right) = \sum (W(FB) \times EF \times GWP) \text{ - Equation 1}$$

CF_{FB} = Carbon footprint based on food and beverage consumption (t CO_2e per year)

W_{FB} = Weight of the consumed food/beverage in kg

EF = Emission factor in g CO_2e per kg of food/beverage Or else g/kg of food and beverage item

GWP = Global warming potential for the next 100 years according to IPCC 2007

*(14/365)*10^{-6} = converting units of CF_{FB} (g CO_2e for 14 days) into t CO2e per year*

(ii) GHG emissions under electricity consumption at residence

Electricity consumption-associated data (i.e. the rate of consumption (W), model, model number, and time used in minutes) were collected for electrical appliances. Using the collected data, electricity consumption in kilowatt-hours (kWh) was calculated and it was used in calculating total indirect GHG emission based on the electricity consumed per year in t CO_2eq (CF_{EC}). When the W value wasn't reported by the participants, reference values were drawn from websites of the Presidential task force on energy demand side management, Lanka Electricity Company (Pvt) Ltd (LECO) and Daft Logic. The beta version of the GHG emission calculation tool (WRI, 2021) was used for calculating CF_{EC} using country-specific emission factors for electricity consumption (Brander et al., 2011).

(iii) Travel behaviour associated with GHG emission

The beta version of the GHG emission calculation tool (Greenhouse Gas Protocol, 2021) was used in calculating travel-associated GHG emissions (i.e. GHG emissions due to use of personal vehicle/s and employee commuting) per year in tonnes CO_2eq (t CO_2eq; CF_{TB}). Participants' self-reported travel data: travel distance in kilometers (km), method of travel, and fuel source/s were collected. Default emission factors provided by the calculation tool for mobile combustion and transportation were used in the calculation.

(iv) Solid Waste (SW) disposal (at resident) behaviour associated GHG emission

Data on waste segregation, type/s of SW, waste disposal method/s and weight of collected SW was collected from each participant. A weighing scale (maximum weight: 50 kg, d = 10 g) was provided to measure the weight of the collected SW. The default method of the IPCC tier 1 approach (Equation 2) was used to estimate CH_4 emissions from solid waste sent to disposal sites in Gigagrams per year (Ggyr^{-1}). Equation 3 was used in estimating CO_2 in Ggyr^{-1} from open burning of SW.

$$CH(4)\ emissions = [(SW(T) * SW(F) * L0) - R] * (1 - OX)] \text{ - Equation 2}$$

Where:

SW_T = Total SW generated (Ggyr^{-1})

SW_F = Fraction of SW disposed at a solid waste disposal site

L_0 = Methane generation potential [MCF • DOC • DOCF • F • 16 / 12 (Gg CH_4/Gg waste)]

MCF = Methane correction factor (*default = 0.4*)

DOC = Degradable organic carbon (*calculated using Equation 5.2 in the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, pg 5.9*)

DOC_F = Fraction DOC dissimilated *(default = 0.77)*

F = Fraction by volume of CH_4 in landfill gas *(default = 0.5)*

R = Recovered CH_4 (Gg/yr) *(default = 0)*

OX = Oxidation factor *(default = 0)*

$$CO(2)\ Emissions = MSW * \Sigma(j)\ [WF(j) * dm(j) * CF(j) * FCF(j) * OF(j)] * 44/12$$

- Equation 3

Where:

CO_2 emissions = CO_2 emissions in inventory year, ($Ggyr^{-1}$)

SW = total amount of municipal solid waste as wet weight open-burned, Gg/yr

WF_j = fraction of waste type/material of component *j* in the SW (as wet weight open burned)

dm_j = dry matter content in the component *j* of the SW open-burned, (fraction)

CF_j = fraction of carbon in the dry matter (i.e. carbon content) of component *j*

FCF_j = fraction of fossil carbon in the total carbon of component *j*

OF_j = oxidation factor, (fraction)

44/12 = conversion factor from C to CO_2

with: $\Sigma_j\ WF_j = 1$

j = component of the SW open-burned such as paper/cardboard, textiles, food waste,

wood, disposable nappies, rubber and leather and plastics.

Global warming potential (GWP) of CH_4 (GWP = 25) and CO_2 (GWP = 1) for the next 100 years according to IPCC (IPCC, 2014b) were used in setting the GHG emission due to solid waste disposal in t CO_2eq (carbon footprint based on the SW disposal at unmanaged disposal sites; CF_{SWDS}, carbon footprint based on the SW open burning; CF_{OB}).

2.5.3 Positive Lifestyle Habits (PLH)

Perception-based assessment on PLH was done using 22 self-reported statements (PLH scale; eg. *I have a good control over my food consumption pattern, I am not harsh on people who are angry with me, I rarely feel guilty about my mistakes, Unfair events make me angry*) on a 5-point Likert scale; 5 – strongly agree and 1 – strongly disagree. Ten items of the PLH scale were reversed-score items. When the total score of the aforementioned perception-based assessment is high, it indicates that the person has more positive habits in his or her daily life. The Cronbach's alpha level for the PLH scale was 0.70.

2.5.4 Perceived Quality of Life (perceived QoL)

The discriminant and convergent validity ensured a brief *Sinhala* version of the World Health Organization-Quality of Life questionnaire (WHO-QOLBREF) (Kumarapeli et al., 2006) was used in assessing perceived QoL. It provides for a detailed analysis of each domain (DOM; 1. physical health, 2. psychological health, 3. social relationships, and 4. environment) of quality of life. Respondents rated 26 items using a Likert scale (1 -Not at all, 2 - Not much, 3 – Moderately, 4 - A great deal, 5 - Completely) based on the perceptions of quality of life for two weeks before answering the questionnaire. SPSS syntax for carrying out data checking, cleaning and computing total scores (WHO, 1996) was used in calculating domain scores. The Cronbach's alpha level for the overall scale was 0.90.

2.5.5 Statistical analysis

IBM SPSS 23 statistical software was used in the statistical analysis. The Shapiro-Wilk test was conducted for checking the normality of data sets. Parametric and non-parametric bivariate correlational tests under 95 % confidence level were conducted to identify possible correlations between study variables.

To conduct mediation analysis, we used the Hayes PROCESS macro for SPSS (Hayes and Scharkow, 2013) with 5000 bootstrap samples. A bias-corrected bootstrap-confidence interval (CI) for the product of hypothesized paths in mediation that does not include zero (Preacher and Hayes, 2008) was considered evidence of a significant indirect effect. Co-variates were controlled under the mediation analyses.

3 Results

Carbon footprints except for $CF_{FB,}$ NYP and SD were not normally distributed. Correlations among meditation experience, perceived QoL and CF are indicated in Table 2.1 and Table 2.2. All facets of trait mindfulness are strongly associated ($r > 0.4$) with PLH. Observing and non-reactivity to present moment experience were only the facets of trait mindfulness which showed significant strong correlations ($p < 0.05$) with all domains of perceived QoL.

364

365 ***Table 2.1 Pearson correlations and descriptive statistics for normally distributed variables; PLH, perceived (P.) QoL, trait mindfulness***
366 ***and CF_{FB}***

Variable		i	ii	iii	iv	v	vi	vii	viii	ix	x	xi	xii
i	PLH	1											
ii	Total mindfulness	0.66**	1										
iii	FFMQ-i	0.55**	0.76**	1									
iv	FFMQ-ii	0.55**	0.80**	0.79**	1								
v	FFMQ-iii	0.45*	0.75**	0.45*	0.40*	1							
vi	FFMQ-iv	0.46*	0.87**	0.60**	0.61**	0.71**	1						
vii	FFMQ-v	0.50*	0.66**	0.23	0.28	0.34	0.48*	1					
viii	DOM1	0.61**	0.47*	0.57**	0.55**	0.16	0.38	0.21	1				
ix	DOM2	0.58**	0.69**	0.65**	0.67**	0.46*	0.64**	0.30	0.76**	1			
x	DOM3	0.50*	0.45*	0.46*	0.40	0.06	0.31	0.49*	0.45*	0.57**	1		
xi	DOM4	0.50*	0.44*	0.47*	0.51**	0.03	0.32	0.36	0.57**	0.58**	0.66**	1	
xii	CF_{FB}	-0.16	-0.39	-0.28	-0.51**	-0.06	-0.27	-0.30	-0.21	-0.37	-0.66**	-0.45*	1

***. Correlation is significant at the 0.01 level (2-tailed).*

**. Correlation is significant at the 0.05 level (2-tailed).*

FFMQ-i: non-reactivity, FFMQ-ii: observing, FFMQ-iii: acting with awareness, FFMQ-iv: describing, FFMQ-v: non-judging of experience

DOM1 – P. QoL based on physical health, DOM2 – P. QoL based on psychological health, DOM3 – P. QoL based on social relationships, DOM4- P. QoL based on surrounding environment

Table 2.2 Spearman's rho values for not normally distributed Temporal variables of meditation experience (RYP, AtMS) and individual CF-associated data sets (CF_{EC}, CF_{TB}, $CFSW_{SWDS}$, $CFSW_{OB}$)

Variable	RYP	AtMS	CF_{EC}	CF_{TB}	$CFSW_{SWDS}$	$CFSW_{OB}$
PLH	0.16	0.25	-0.34*	0.13	-0.08	0.07
Total mindfulness	0.05	0.21	-0.11	0.40*	0.34	-0.12
FFMQ-i	0.26	0.43*	-0.21	0.24	0.04	-0.02
FFMQ-ii	0.12	0.18	0.07	0.32	0.19	-0.09
FFMQ-iii	0.15	0.01	-0.27	0.53**	0.53**	-0.27
FFMQ-iv	0.26	0.28	-0.14	0.34	0.21	-0.12
FFMQ-v	-0.36	0.02	-0.13	0.22	0.09	-0.12
DOM1	0.25	0.39	-0.27	0.09	-0.03	0.12
DOM2	0.34	0.37	-0.24	0.12	0.18	-0.13
DOM3	-0.11	0.32	-0.14	-0.06	-0.20	0.02
DOM4	-0.07	0.36	-0.21	-0.13	-0.12	0.28
RYP	1	0.42*	-0.16	-0.01	-0.01	-0.05
AtMS	0.42*	1	-0.28	-0.09	-0.23	0.16
CF_{EC}	-0.16	-0.28	1	0.01	0.14	-0.23
CF_{TB}	-0.01	-0.09	0.01	1	0.62**	-0.43*
$CFSW_{SWDS}$	-0.01	-0.23	0.14	0.62**	1	-0.53**

$CFSW_{OB}$	-0.05	0.16	-0.23	-0.43*	-0.53**	1

***. Correlation is significant at the 0.01 level (2-tailed).*

**. Correlation is significant at the 0.05 level (2-tailed).*

FFMQ-i: non-reactivity, FFMQ-ii: observing, FFMQ-iii: acting with awareness, FFMQ-iv: describing, FFMQ-v: non-judging of experience

DOM1 – P. QoL based on physical health, DOM2 – P. QoL based on psychological health, DOM3 – P. QoL based on social relationships, DOM4- P. QoL based on surrounding environment

Although we expected negative correlations between mindfulness and CF, the CF_{TB} and CF_{SWDS} showed significant positive associations with the facet of acting with awareness of trait mindfulness ($p_{(CFTB/CFSWSD-(FFMQ-iii))} < 0.01$). Similarly, CF_{TB} positively correlated with total trait mindfulness ($p < 0.05$). Observing facet of mindfulness showed a significant negative correlation with CF_{FB} ($p < 0.01$).

Results revealed that PLH significantly mediates the relationship between observing facet of trait mindfulness and CF_{FB} (indirect effect - 0.002, SE = 0.001 95% CI [0.010, 0.417]) which warranted accepting Hypothesis 1 (Figure 1). Hypothesis 2 was rejected as there was no significant indirect effect of trait mindfulness on CF_{TB} through PLH (indirect effect - 0.002, SE = 0.017 95% CI [-0.028, 0.039]; Figure 2). Hypothesis 3 was not rejected as there was a significant indirect effect on the relationship between acting with awareness and CF_{SWDS} through PLH (indirect effect – (-0.003), SE = 0.003 95% CI [-0.0124, -0.0001]; Figure 3).

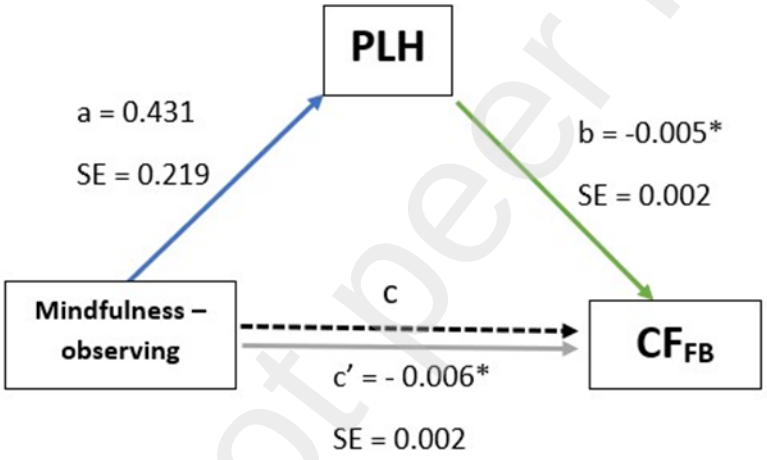

Figure 1: Path coefficients for the mediation model- Hypothesis 1

C = -0.004, SE = 0.002

Note. The dotted line denotes the effect of observing facet of mindfulness on CF_{FB} when PLH is not included as a mediator.

"a", "b", "c" and "c′ " are unstandardized ordinary least square regression coefficients.

*p < 0.05

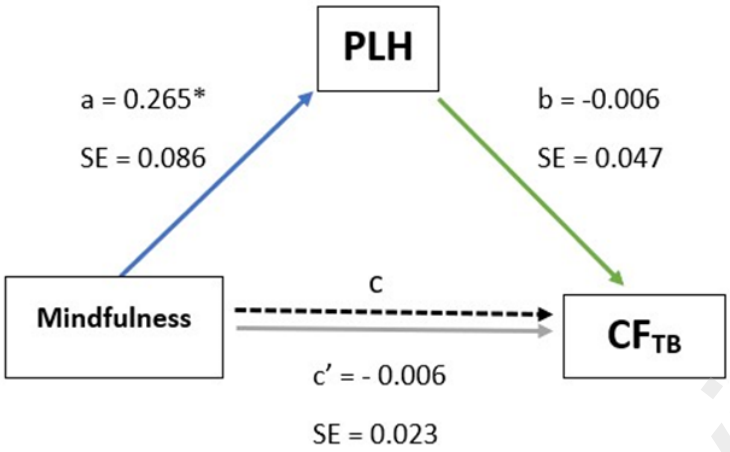

Figure 2: Path coefficients for the mediation model- Hypothesis 2

C = 0.008, SE = 0.018

Note. The dotted line denotes the effect of observing facet of mindfulness on CF_{TB} when PLH is not included as a mediator.

"a", "b", "c" and "c′ " are unstandardized ordinary least square regression coefficients.

*p < 0.05

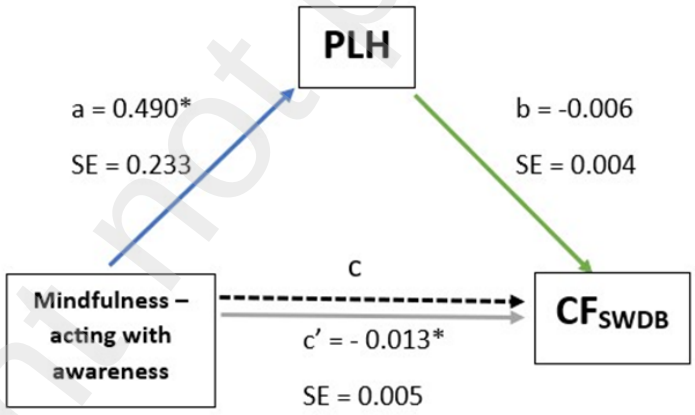

Figure 3: Path coefficients for the mediation model- Hypothesis 3

C = 0.011, SE = 0.005

Note. The dotted line denotes the effect of acting with awareness facet of mindfulness on CF_{SWDS} when PLH is not included as a mediator.

"a", "b", "c" and "c′ " are unstandardized ordinary least square regression coefficients.

*p < 0.05

4 Discussion

The present research conducted an in-depth analysis on the relationships among meditation, PLH, perceived QoL and per-head CF. The study found no significant correlations between temporal variables and PLH, perceived QoL and per-head CF. Trait mindfulness which was considered as a variable of meditation experience significantly connected with PLH, per-head CF, and perceived QoL. Investigations on the insights into how and why meditation experience influences per-head CF provide evidence for the mediating role of PLH in the relationship between meditation experience and per-head CF.

The findings of the current study revealed that the relationships between trait mindfulness (i.e. as a variable of meditation experience) and carbon emission based on solid waste disposal behaviour/food-beverage consumption behaviour are partially mediated by PLH. To our knowledge, there is no previous research specifically examining the mediating role of PLH in the relationship between meditation and per-head CF. However, it is plausible that PLH could mediate this relationship, as meditation has been shown to promote a wide range of positive lifestyle habits that are associated with reduced carbon footprints, such as mindful consumption and improved physical activity. Moreover, we believe that as a variable of meditation experience, trait mindfulness makes alternative behavioural choices through meditation and brings positive impacts on lifestyle behaviours and attitudes which may promote nature-friendly, suitable behaviours. Such promotions may lead to engagement in behaviours which cause minimal emission of Carbon to the atmosphere.

The observed low path coefficients in mediation models may be due to the final sample size in the present study. However, as suggested by Schoemann et al. (2017), 0.7 which was obtained as the power of the final sample size in the present study is often considered sufficient for detecting effects in mediation analysis with three variables. Moreover, the sample size of the present study was the optimum sample size which could be found depending on the process followed in participant screening for the present study as mentioned under the methodology. Baminiwatta et al., (2022) mentioned that out of the whole study units, only 21 % practised meditation and only 1.9 % of regular meditation practitioners followed Vipassana meditation. This indicates that even if the Vipassana meditation is popular in Sri Lanka, identifying a large sample of long-term experienced meditation practitioners could be quite difficult, especially for scientific research. Moreover, it may be taken more time and effort. Therefore, longitudinal research on the topic of present study is recommended for future researchers. Further, indirect effect values presented through this research paper can be considered in sample size calculations in future mediation analysis on the same topic.

Though we used multiple variables of meditation experience, most of the previous research did not consider many variables of meditation in the analyses. In addition to the major outcomes of the present study, we observed that with the increase in the duration of a regular mediation session, the ability to have a nonreactive manner to current events (i.e. conscious choice-making) is increased which may cause greater cognitive control as mentioned in Anicha (2012). This is further supported by the observed significant positive correlations of trait mindfulness with PLH and perceived QoL.

Although both traditional Buddhist teachings on meditation and cutting-edge neuroscience have supported the idea that repeated meditation practice is beneficial, not investigating the frequency of meditation is a limitation of the present study. Further, even if Josefsson and Larsman (2011) reported that age and gender as covariates of mindfulness, it was not the same for the sample used in the present research. However, to go in-depth in the analysis of the mediation role of positive lifestyle on the relationship between meditation and carbon emission, this study could be considered

as a preliminary study for future scientific research. The approach of per-head CF data collection followed in the present study is unique in that none of the previous studies on meditation in climate change mitigation has taken measures to quantify per-head CF using long-term data.

Meditation has been shown to have a positive effect on a wide range of lifestyle habits, including physical activity (Tang et al., 2012), healthy eating (Mantzios and Giannou, 2014) and stress management (Khoury et al., 2015). One of the key benefits of meditation is that it helps individuals become more aware of their thoughts, emotions, and behaviours (Creswell, 2017; Hölzel et al., 2011; Lutz et al., 2015). By increasing self-awareness, meditation may help individuals in identifying negative patterns of behaviour and making more conscious choices about their lifestyle habits. These might be the reasons behind the observed significant relationship between trait mindfulness and PLH. Moreover, Zeidan et al., (2011) suggest that meditation can improve emotional regulation by increasing activity in the bilateral Orbitofrontal Cortex (OFC), a brain region that plays a key role in regulating emotions. By improving emotional regulation, meditation may help individuals to cope with negative emotions and stressors in a more adaptive way, making them resort to more positive lifestyle behaviours.

Chiesa and Serretti (2010) found that meditation improves attention and cognitive function in healthy individuals. It leads to better performance in tasks that require cognitive control, working memory, and other cognitive abilities. By improving cognitive function, meditation may improve perceived QoL in areas such as work and relationships, where cognitive skills are often necessary for success. Previous research has shown that individuals who score higher on the non-reactivity facet of mindfulness tend to have better emotional regulation and coping skills, and may be less likely to engage in unhealthy behaviors as a way of coping with stress (Baer et al., 2006; Garland et al., 2015). This, in turn, may lead to better-perceived QoL, as individuals are better able to manage stress and maintain positive emotional well-being. Further, the significant relationships between the observing facet and perceived QoL in all aspects may be due to the developed sense of detachment and perspective through meditation which may lead to greater emotional stability and resilience.

In the present study, out of all facets of mindfulness, the observing facet and the acting with awareness facet played a significant role with per-head CF. The observing facet of mindfulness is the strongest predictor of the relationship between mindfulness and connectedness to nature, according to Barbaro and Pickett (2015) and Howell et al. (2011). To feel emotions like awe and wonder in the natural world, one must slow down and actively pay attention to it. When one's emotions and sentiments are influenced, he or she is more likely to commit to having acceptable behaviours or avoiding unpleasant behaviours (Bowles, 2011). With the practice of meditation, one’s compassion and sympathy towards nature might be promoted and subsequently, it may lead to positive changes in his or her behaviour at different levels (Lengyel, 2015). Therefore, more mindful people may have fewer greenhouse gas emissions as indicated by the present study.

Further, acting with awareness may grow along with observing. Therefore, the authors of the present research believe that drawing attention to acceptable behavioural options like low carbon-emitting behaviours (e.g. recycling waste, eating plant-based foods) could be promoted through increased awareness which restricts automatic behavioural reactions (Kang et al., 2013) and promotes behavioural management (Chatzisarantis and Hagger, 2007). As mentioned before, meditation has been shown to promote well-being, which may in turn reduce the desire for material possessions and consumption. By reducing materialism and promoting a simpler lifestyle, individuals may be more likely to make choices that are environmentally sustainable and reduce their carbon footprint.

5 Conclusions

The present study contributes to the growing body of knowledge on meditation PLH, perceived QoL and pro-environmental behaviour. In the present study, we have presented (i) possible correlations of meditation experience with PLH, perceived QoL and per-head CF and (ii) statistical models illustrating a relevant and broad potential mechanism underlying the observed significant associations between meditation experience and the per-head CF. The findings of the present study suggest that meditation experience correlates with PLH, perceived QoL and per-head CF of a skilled meditator and PLH plays a mediating role in the relationships between meditation experience and per-head CF. As this is the 1st attempt made by a team of environmental researchers to study the role of meditation in per head CF along with PLH and perceived QoL, the findings of the present study are important for future researchers to design more comprehensive research designs on the topic of the present study. Based on the results of the present study, in future, meditation-based interventions can be investigated in promoting low-carbon lifestyles and perceived QoL.

6 Availability of data and material

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

7 Ethics statement

This study was approved by the Ethics Review Committee of Faculty of Medicine (FOM) at University of Colombo (UOC), Sri Lanka (EC/19/103). All participants provided informed consent to participate in the study.

8 Conflicts of interest

The authors declare that they have no conflict of interest.

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Supplementary Material

How does meditation relate to quality of life, positive lifestyle habits and carbon footprint ?

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10 Supplementary Data – ANNEX 1

Research tool/ research method	**Feasibility of research procedures**
Screening process	Fourty three percent of experienced long-term meditators was eligible for the main study as "skilled meditators". Overall adherence rate of the study after the screening process (considering the present study) - 83.33 %
Administering the BMEQ	n = 10 Responding time range (minutes) = (15 – 20) Response rate = 100.00 %
Administering the CNS	n = 10 Responding time range (minutes) = (5 – 10) Response rate = 100.00 %
Administering the FFMQ	n = 10 Responding time range (minutes) = (8 – 13) Response rate = 90.00 %

GHG emission data recording	1st pilot study - n = 10, given data recording time period – 7 usual days Dropout rate; recording food and beverage data – 77.78 % Dropout rate; recording electricity consumption data – 11.11 % Dropout rate; recording travel behaviour data – 22.22 % As the dropout rates were so high, changes were made in the GHG recording data sheets (Complex → Simple by changing the structure of data collection sheets, adding examples as guidance to record data under each domain of data recording). Time duration of data recording was also changed as 14 days of one's usual life routine. Dropout rates were checked for the updated data collection sheets among 27 skilled meditators. Dropout rate; recording food and beverage data – 7.14 % Dropout rate; recording electricity consumption data – 7.14 % Dropout rate; recording travel behaviour data – 7.14 % Dropout rate; recording solid waste disposal associated data – 14.28 % Reasons for dropping out data recording:

	2 participants – personal health issues occurred during the data recording period Other 2 participants – without giving reasons, data recording under solid waste disposal behaviour was rejected. Reminders were sent to all participants every 3 days during the experimental period (30 days).

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