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Review Article

Nursing Section

Predictors of Heart Rate Variability: A Systematic Review

RANI JOSE[1], NEETHA KAMATH[2], SREEJA GOPALAKRISHNAPILLAI[3], SALINA SUNIL[4]

ABSTRACT

Introduction: The heart has the ability to maintain cardiac output in accordance with the body's momentarily changing demands by adjusting its rate of contractions and this ability is termed Heart Rate Variability (HRV), which is manifested as a fluctuation of R-R interval in milliseconds on an Electrocardiography (ECG). Maintenance of good HRV levels is significant for the patient population since they influence the prognosis and quality of life.

Aim: To identify the predictors of HRV.

Materials and Methods: The present study was a systematic and literature review which was based on Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) guidelines 2020. Randomised Controlled Trials (RCTs) published in English from 2014 to 2021 were identified from Cochrane Library, Science Direct, PubMed, and Google Scholar databases. The keywords with Boolean operators were used as "influencing factors or determinants or predictors and HRV." The quality assessments of the studies were performed with Cochrane risk-of-bias assessment tool. Narrative syntheses upon the selected studies were done.

Results: The significant findings from the nine selected RCTs were summarised. Physical exercise, breathing exercise, diet, music, and mind-body interventions such as yoga and meditation were identified as the factors enhancing HRV or predictors of HRV.

Conclusion: The findings of this systematic review strive to facilitate healthcare providers to devise the strategies to support the risk group of low HRV by the implementation of enhancing factors of HRV to achieve a better outcome.

Keywords: Determinants, Exercises, Influencing factors

INTRODUCTION

The heart is a unique organ with a capacity to maintain cardiac output in accordance with the body's momentarily changing demands by adjusting its rate of contractions. This ability is termed HRV, manifested as a fluctuation of R-R interval in milliseconds on an ECG. A person with high HRV can be considered healthy in terms of physical, social, mental, and spiritual aspects. Measurement and maintenance of good HRV levels are significant for the patient population since they influence the prognosis and quality of life [1]. The heart rate is modulated by a balance between the sympathetic and parasympathetic systems. The neurocardiac function reflects the interaction between the heart and brain, measured by the HRV. Hence, researchers and clinicians worldwide use HRV to measure the heart's autonomic control [2]. HRV is an emerging concept in the field of medical treatment, and the available empirical data on the factors affecting HRV are scattered. Many factors can influence HRV. Several studies were conducted to identify, the influence of individual factors on HRV. According to a review, physiological, pathological, neuropsychological, lifestyle, and environmental factors can influence HRV [3]. The studies involving a compilation of the factors which can enhance HRV may facilitate the healthcare providers to devise strategies to support the risk group of low HRV. The enhancement of HRV is directly related to Parasympathetic Nervous System (PNS) activation [4]. The present systematic review addresses the research question, that what are the factors enhancing HRV. The main objective was to identify the positive predictors of HRV.

MATERIALS AND METHODS

Search Strategy

The review followed the guidelines of PRISMA 2020 [5]. The Prospero Id for the review was registered as CRD42021270016. The steps for conducting the systematic review comprised locating the sources, selecting the studies, and quality appraisal of studies, followed by the presentation of findings. A systematic review of literature for articles in the English language, published from 2014 to 2021, was conducted using electronic databases such as Cochrane Library, Science Direct, PubMed, and Google Scholar. The keywords used for the search were "influencing factors", "HRV" combined with Boolean operators "AND" and "OR" with the synonyms "determinants" and "predictors". In addition to the above, a reference list of all relevant articles and reviews was checked.

Inclusion criteria

- Type of study- RCTs published between 2014-2021
- Language-English
- Study participants-Adults of both gender aged above 18 years
- Full-text article availability.

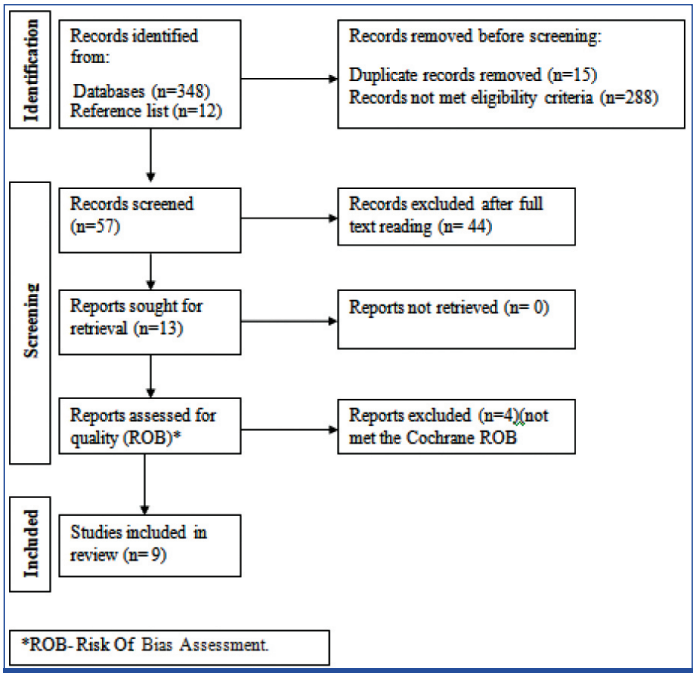
Exclusion criteria

Articles on-

- Paediatric population,
- Pregnant and lactating mothers.

After identifying the records through databases and reference lists, duplicates were removed manually. Two levels of screening were completed independently by three authors, the first level was the screening of title and abstracts, and the second level was the full-text screening of eligible studies. Disagreements concerning article inclusion were resolved within the group discussion. Three reviewers worked independently to reduce the chance of error, add more scrutiny, and ensure proper conduct.

The literature search in various databases and reference list of other relevant articles yielded 360 studies. After excluding 15 duplicates, there were 345 articles, of which 288 articles that were not relevant based on the selection criteria were excluded, and the remaining 57 records were identified for screening. Another 44 studies were also eliminated as they had multiple outcome measures other than factors influencing HRV. A risk-of-bias assessment screening was done for the remaining 13 records, and four studies were eliminated. Ultimately, nine studies were considered for data synthesis. The study selection process is depicted in PRISMA [Table/Fig-1] [5].



[Table/Fig-1]: Flowchart of the literature search process (PRISMA 2020) [5].

Quality Assessment and Data Extraction

The methodological qualities of the studies were evaluated independently by two authors. An assessment of the 'risk-of-bias' was done using the Cochrane risk-of-bias assessment tool for randomised trials [6]. The tool categorises the risk as high, low, or uncertain according to the description of the study with reference to the methodology. The researchers compared the scores after they were measured independently by the researchers [Table/Fig-2] [7-19].

Three reviewers extracted data using a predesigned data extraction sheet to allow standardised reporting of results across studies.

RESULTS

The study characteristics extracted from each review were as follows: Basic information of the study, including the year of publication, author, participants, interventions, and outcome [Table/Fig-3] [7,10,11,13-16,18,19].

As the studies included were heterogeneous in outcome measures, a narrative synthesis of the data was conducted. The significant findings from the nine selected RCTs were summarised. Physical exercise, breathing exercise, diet, music, and mind-body interventions such as yoga and meditation were identified as the factors enhancing HRV or predictors of HRV [Table/Fig-4] [7,10,11,13-16,18,19].

Author/Publication year	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome data	Incomplete outcome data	Selective reporting	Other bias
De Couck M et al., (2019) [7]	x	x	_	x	x	?	?
Berger M et al., (2019) [8]	?	_	_	_	x	x	x
Dunne PJ et al., (2019) [9]	x	_	_	x	?	_	x
Masroor S et al., (2018) [10]	x	_	?	x	x	x	x
Fiogbé E et al., (2018) [11]	x	_	x	?	x	x	x
Matos M et al., (2017) [12]	x	_	_	_	_	_	_
Ramírez-Vélez R et al., (2020) [13]	x	x	x	?	x	x	?
Warth M et al., (2016) [14]	x	x	x	x	?	_	x
Chu I-H et al., (2017) [15]	x	x	?	?	x	x	?
Caruso FR et al., (2015) [16]	?	x	x	_	_	x	x
Azam MA et al., (2015) [17]	x	_	x	_	x	_	_
Sauder KA et al., (2014) [18]	x	?	x	x	_	x	_
Lin IM et al., (2014) [19]	x	_	_	_	x	x	x

[Table/Fig-2]: Cochrane risk of bias assessment for RCT [7-19].
x-Low, - High, ?-Unclear

Author	Publication year	Participants	Type/Nature of of Intervention	Results
De Couck M et al., [7]	2019	30 healthy people	Two types of breathing pattern (symmetric and skewed pattern)	Both types of breathing pattern, increased most HRV parameters.
Masroor S et al., [10]	2018	28 hypertensive sedentary women- (15 in experimental and 13 in control group)	Aerobic and resistance exercise of moderate intensity five times/week for four weeks	The intervention group demonstrated an increase in HFnu, TP, SDNN, and RMSSD, ($p<0.05$) along with a significant decrease in LFnu, LF/HF ratio, systolic blood pressure, and diastolic blood pressure ($p<0.05$).
Fiogbé E et al., [11]	2018	26 male with CAD (14 in treatment group and 12 in control group)	Water Aerobic Exercise Training (WAET) consisted of three weekly sessions on alternate days, totalling 48 sessions.	The training group participants demonstrated improvement in the HRV indices.
Ramírez-Vélez R et al., [13]	2020	21 physically inactive adults (10 in moderate- continuous training group, 11 in high intensity training group)	Moderate- continuous training versus high intensity training for 12 weeks	High intensity training program increased the short term HRV, mainly in vagally mediated indices.
Warth M et al., [14]	2016	84 (42 in music therapy and 42 in mindfullness exercise)	Music therapy/mindfulness exercise for 20 minutes	Higher levels of vagally mediated heart rate variability (VM-HRV) and significantly stronger were present with the music therapy group.
Chu IH et al., [15]	2017	26 (13 in yoga and 13 in control group)	Breating exercise, asana practice meditation and relaxation, totally for 60 minutes	The intervention group had a significant increase in HF-HRV and decreases in LF-HRV and LF/HF, while no significant change was found in the control group. The SDNN was shown to increase in the intervention group and decrease in the control group.
Caruso FR et al., [16]	2015	20 (10 in usual care and 10 in Resistance Training Group (RTG))	High Repetition/Low Load Resistance Training (HR/LL-RT) program for eight weeks	There was a significant improvement in RMSSD at the eight weeks assessment in the RTG only.

Sauder KA et al., [18]	2014	30 (randomised, cross-over, controlled feeding design)	Low fat control diet and moderate fat diet containing pistachios for four weeks each, seperated by a two week wash out.	Study identified improvements in three indices of HRV following pistachio consumption: RMSSD, high frequency, and low frequency
Lin IM et al., [19]	2014	47 healthy college students	Breathing exercises at different rates and I:E ratio for 22 minutes (breathing rates (6 and 5.5 breaths) and I:E ratios (5:5 and 4:6)	A breathing pattern of 5.5 bpm with an I:E ratio of 5:5 achieved greater HRV than the other breathing pattern.

[Table/Fig-3]: Characteristics of included studies [7,10,11,13-16,18,19].
HF nu: High frequency power normalise units; LF/HF ratio: Ratio of low and high frequency power; TP: Total power; SDNN: Standard deviation of N-N intervals; RMSSD: Square root of the mean squared differences between adjacent RR intervals; LF nu: Low frequency power normalise units; CAD: Coronary artery diseases; I:E ratio: inhalation-to-exhalation ratio

Predictors of HRV	Literature sources	Year	Conclusion
Physical Exercise	Masroor S et al., [10] Fiogbé E et al., [11] Ramírez-Vélez R et al., [13] Caruso FR et al., [16]	2018 2018 2020 2015	Aerobic and resistance training exercises (walking, stretching and, water exercises) improves HRV
Breathing Exercise	De Couck M et al., [7] Chu IH et al., [15] Lin IM et al., [19]	2019 2017 2014	Breathing rate of 5.5 bpm with an I:E ratio of 5:5 , symmetric and skewed patterns of breathing exercises, significantly increases HRV
Yoga and Meditation	Chu IH [15]	2017	Practice of Asanas, Meditation and Relaxation techniques promotes HRV
Diet	Sauder KA et al., [18]	2014	A moderate-fat diet containing pistachios modestly improves HRV
Music	Warth M et al., [14]	2016	Music therapy can significantly reduce vascular sympathetic tone and improves vagally-mediated heart rate variability

[Table/Fig-4]: Predictors of heart rate variability [7,10,11,13-16,18,19].

DISCUSSION

HRV is the outcome of the dynamic interaction of various body systems. It is now used as a standard indicator of health. Understanding the following influencing factors of HRV helps healthcare providers in their daily practice in different clinical contexts [2]. Physical exercises such as combined aerobic and resistance training [10], water exercises [11], stretching [13], and interval training [16] enhance HRV. Exercise duration between 6-24 weeks, for atleast three times per week, is sufficient to influence HRV positively [20]. A systematic review identified interval training as an efficient method for cardiorespiratory variables. The acute stretching exercise was a helpful therapeutic intervention to improve cardiac autonomic function in different populations [21]. Walking is associated with enhanced PNS activity and improved HRV [22,23].

The frequency and amplitude of respiration modulate the pattern of heart rhythm known as respiratory sinus arrhythmia. So, cognitively directed breathing exercises can highly influence HRV in a positive manner [7,15,19]. An experimental study identified the influence of metronome breathing upon HRV with age and postural variations. HRV and respiratory sinus arrhythmia were promoted by breathing techniques paralleled by central nervous system activity modifications. A slow breathing technique was indicated by an increase in alpha and a decrease in theta power during EEG monitoring [24]. Many sources of stress, such as anxiety, hostility, depression, work stress, and negative emotions, induce low HRV. Mind body interventions such as mindfulness meditation, yoga, qigong/tai chi, etc., improve HRV by increasing parasympathetic tone [3,15,25,26].

The literature also identified the positive influence of compassionate care on HRV [27,28]. In a thesis, it is identified that forgiveness improves HRV, and forgiveness influences physical health through mechanisms of cardiac autonomic control ([29]-unpublished, waiting to be published). A randomised pilot study revealed that, gratitude journaling improves parasympathetic HRV responses [30]. As per a review, a moderate-fat diet containing pistachios improves the measures of HRV [18]. Another review explains that the mediterranean diet, omega-3 fatty acids, B vitamins, probiotics, and polyphenols enhance HRV. In a cross-sectional study, wine intake was associated with increased HRV. On the other hand, the consumption of beer and spirits and the total amount of alcohol consumed did not relate significantly to the HRV parameters [31,32]. Another systematic review identified that music benefits the cardiovascular system [33]. Hence, with music therapy, HRV can be increased, and there will be reduced sympathetic activation.

The clinical implementation of this systematic review finding was significant for a holistic approach to patient care. In light of this, it may be suggested that an intervention comprising positive predictors of HRV be developed and an extensive prospective evaluation of the intervention should be conducted.

Limitation(s)

In the present review, a formal meta-analysis was not considered appropriate due to the considerable variations in the analysed HRV parameters and assessment contexts (e.g., short term versus long term recordings of HRV).

CONCLUSION(S)

Keeping an elevated HRV level plays a significant role in a person's personal and social life. It contributes much to his/her physical, mental, social, and spiritual well-being. The findings of this systematic review strive to facilitate healthcare providers and devise strategies to support the risk group of low HRV and to achieve a better outcome.

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PARTICULARS OF CONTRIBUTORS:
1. Professor, Department of Medical Surgical Nursing, Government Nursing College, Kannur, Kerala, India.
2. Associate Professor, Department of Community Health Nursing, NITTE Usha Institute of Nursing Sciences/NITTE Deemed to be University, Mangalore, Karnataka, India.
3. Professor, Department of OBG Nursing, Government Nursing College, Kannur, Kerala, India.
4. Associate Professor, Department of Community Health Nursing, College of Nursing, Thalassery, Kerala, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Neetha Kamath,
Kotekar Beeri Road, Paneer, Deralakatte, Mangalore, Karnataka, India.
E-mail: neethakamath@nitte.edu.in

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