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EFFECT OF BREATHING EXERCISES, MEDITATION AND COLD EXPOSURE ON RESTING HEART RATE: AN EXPERIMENTAL N=1 STUDY

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Abstract

Introduction: The Wim Hof Method (WHM) is a behavioural intervention that integrates breathing techniques, meditation and cold exposure in to every day life. Few data exist on the association between practicing the WHM training program and cardiovascular outcomes. This study sought to examine the association between practicing this training program and lowering the resting heart rate (RHR). **Method:** In March and April 2021, one participant of 21 years old without severe comorbidity and no routine experience of practicing the WHM training program tracked his RHR with 6 days without intervention for baseline purposes, and 33 days while practicing the WHM training program. **Results:** There was a significant reduction in RHR (P = <0.05) compared with the preintervention period. No related serious advents events were reported. **Discussion:** A routine WHM training program resulted in a statistical significant reduction of RHR. Certain patients, for example angina pectoris patients, should be carefull when conducting the WHM training program (especially the cold exposure element). The developer of the WHM, suggests that this reduction in RHR is because of acute vasoconstriction during the cold exposure. According to this theory this should result in chronically vasodilatation, which in his turn results in a reduction of the heart workload. Emprical data for confirming this hypothesis is limited. More RCT studies on the WHM training program and cardiovascular diseases are recommended.

1. Introduction

“Cardiovascular diseases" (CVD) is a collective term for a large number of diseases of the heart and blood vessels [1], including for example coronary heart disease or cardiomyopathy. According to the Dutch National Institute for Health and Environment [2] in The Netherlands alone, there were an estimated 1.7 million people with cardiovascular diseases in 2019. These data also show that at 10.2 billion-euro, cardiovascular health care expenditure accounted for 11.7% of total health care expenditure in the Netherlands. According to the Dutch general practitioners society [3], exercising is important for preventing these kind of diseases.

The new Dutch Health Council recommendation [4] is to exercise moderately intensively for at least 150 minutes a week. In addition, the Council recommends muscle and bone strengthening exercises, such as climbing stairs, jumping or gardening. In 2019, In the Netherlands, the new exercise guidelines for moderately intensive exercise and bone and muscle strengthening activities are met by 47,5% of the Dutch population from 4 years of age [5].

A predictor for CVD that has been widely described in the literature is an elevated resting heart rate (RHR). The RHR is defined as the number of times the heart beats within a minute when an individual is not active [6]. A strong association between elevated RHR and CVD risk has been shown, and this association appears to be independent of other major risk factors for atherosclerosis [7]. This suggests that elevated RHR does not only predict outcome, but that elevated RHR may be a true cardiovascular risk factor and a causal determinant of cardiovascular disease [8]. As stated above, exercising to decrease the prevalence of CVD has been neglected by more than half of the Dutch population. A possible intervention for decreasing the prevalence of CVD is by promoting exercise through motivational interviewing [9]. However this only has a small effect in increasing physical activity level in individuals, especially when a chronic health condition is diagnosed [10]. Besides techniques as motivational interviewing to promote exercising, what can be done further to decrease RHR?

A possible intervention has been recently described by a Dutch athlete with the nickname "the Ice-Man", Wim Hof. He is known for several world records [11] and has developed the so called Wim Hof Method (WHM) which contains 3 interventions; breathing exercises, meditation and cold exposure. In Wim Hof his latest book [12], he claims that practicing the WHM can also reduce RHR, to prevent cardiovascular diseases of which some of them are described in the section above. There has been no scientific research conducted about the WHM training program in relation to the cardiovascular system while writing this paper. However, since 2007 there has been several other scientific studies for benefits of the WHM training program, and it has been shown that participants who practice the WHM training program can voluntary influence the sympathetic nervous system and immune system [13-15]. Would it therefore also be possible to decrease the RHR by practicing the WHM training program, and for this decreasing the chance of CVD? Therefore, in the present study, the effects of the WHM training program on a cardiovascular system parameter in a healthy male was monitored. A research question was stated; "what is the effect of practicing the Wim Hof Method on resting heart rate after 33 days?".

As stated above, the objective in the present study was to seek any influence on the RHR when practicing the WHM training program for a period of 33 days (excluding 6 days of baseline measurements). In addition to the research question, 2 hypothesis were described. H0: There is no significant difference in RHR after practicing the WHM training program on a daily basis in 33 days. Ha: There is a significant difference in RHR after practicing the WHM training program on a daily basis in 33 days.

2. Method

2.1 Design

This quantitative study is an experimental prospective research with a longitudinal study design. The intervention will be used as preventive in this study, because the participant has no CVD at the start of the study, of which more information will be described below. There will be a baseline measurement period that will take 6 days, following a intervention period of 33 days. The baseline measurement period refers to a period in which the WHM is not performed, but the RHR measurement procedure (as described below) has been followed (for 6 days).

For registering the RHR of the participant, a pulse oximeter was used. A pulse oximeter, the Medisana PM100 type, is a valid instrument for the assessment of heart rate in healthy adults [16]. To carefully measure the RHR, a measuring procedure was prescribed. This way, the chance that any other cofactor influenced the RHR was minimized. The measuring procedure was followed every morning, for 33 days, right after the participant woke up. All measurements were performed at the same time of day between 6:00AM and 8:00AM.

When starting the pulse oximeter, after a 30 seconds break, the first RHR was noted. With 30 seconds interval, two more RHR data notes were collected. So in total noting the RHR data 3 times through Microsoft Excel Online, to then exporting the data to IBM SPSS Statistics version 26 for analysis.

2.2 Participant

A healthy, sedentary non-smoking men who was 21 years old took part in the study. Participant was not receiving pharmacological treatment known to affect blood pressure or CVD risk factors. Vo2Max and blood pressure measurements were performed before intervention started to measure overall fitness. Vo2Max of 46/ml/min/kg, systolic blood pressure of 115 mm Hg and diastolic blood pressure of 80 mm Hg were measured, no physical limitations that precluded WHM training program participation were observed. Contraindications for taking part of the WHM training program are advised in his book [12]:

- Epilepsy
- High blood pressure (in case of prescription medication)
- Coronary heart disease (e.g. Angina Pectoris; Stable Angina)
- A history of serious health issues like heart failure or stroke

2.3 Intervention

After 6 days of baseline measurements, the intervention started. The WHM training program was followed using the book [12] that Wim Hof has revealed in October 2020. The WHM training method combines breathing techniques, meditation and cold exposure. These 3 elements were performed by the participant for 33 days, every morning 6:00AM and 9:00AM after measuring the RHR. The routine consisted of:

1. Forced breathing (3 rounds of voluntary hyperventilation followed by holding the breath and deep inhalations and exhalations).

2. Meditation, so-called "third eye meditation," a form of meditation aimed at total relaxation. Focus on deep breathing, setting a goal for the present day. For example; "today I want to stay at least 50 seconds under the cold shower".

3. Body exposure to cold water by showering, starting at 30 seconds long and progressively building up to 2 minutes at day 33.

2.4 Statistical methods

At the end of the study, 39 days (33 intervention days, 6 baseline days) with 3 data points each day of the RHR were collected. The median of these data per day was calculated. In this way, high or low outliers of data will be omitted, in order to show the best possible representation of reality. The statistical analysis compared two groups of data and then concluded whether there was a difference after applying the intervention. Alpha of 0.05 was used. To analyse the RHR, in case of a normal distribution in data the independent-samples T test will be used. In a case of a non-normal distribution, the Mann-Whitney U test will be used. The data of this variable is not related to each other, because the measurement in week 1 has no relationship to the measurement in week 4 e.g.

2.5 Ethical aspects

Prior to this study, a Standard Research File by the CMOO was designed, of which the participant has taken knowledge. After signing the informed consent, the participant agreed on the following:

- I have read the information sheet. I was able to ask questions. My questions have been answered well enough. I had enough time to decide if I wanted to take part.
- I know that taking part is voluntary. I also know that at any time I can decide not to take part in the study. Or to stop taking part. I do not have to explain why.
- I give the investigator consent to inform my doctor that I am taking part in this study.
- I only do this to answer the question of this study.
- I know that some people will be able to see all my data to review the study. These people are mentioned in this information sheet. I give consent to let them see my data for this review.

3. Results

This N1 study has 1 participant, whose characteristics have been described in the methods section. RHR was measured in total of 39 days, 3 times per day, of which the median was used in final data. First 6 days were used as a baseline measurement, during the other 33 days the WHM training program was followed as described in the method section. RHR in before and after the interventions are presented in table 1, with all the data visualised in figure 1 (page 4).

Using skewness and kurtosis analysis, normal distribution of the data was observed for both measuring periods. Therefore, the independent-samples T test with Alpha of 0.05 has been used. There was a reduction in RHR ($P = <0.05$) compared with the preintervention period. No related serious advents events were reported.

WHM intervention	N (days)	Mean RHR	Std. Deviation
no	7	56,57	1,902
yes	33	50,18	2,338

Table 1: Resting heart rate; baseline in comparison with intervention period

4. Discussion

In this study, the question which was tried to be answered was: “what are the effects of practicing the WHM on resting heart rate after 33 days?”. In addition to the research question, 2 hypothesis were described. H_0: There is no significant difference in RHR after practicing the WHM training program on a daily basis in 33 days. H_a: There is a significant difference in RHR after practicing the WHM training program on a daily basis in 33 days. Herein, we show that the effects of the short-term training program are a significantly lowered the RHR, therefore the H0 is rejected.

What are possible explanations for this decrease in RHR? In Wim Hof his book [12], he states that mainly the cold exposure element of the WHM training program has an influence on the RHR. He states that after years of wearing clothes, turning up the heat e.g., the body is not used to “opening and closing” of the vascular to protect ourselves from the cold and heat, resulting in a ‘constructed vascular system’;

“When these little vascular muscles are not tuned up, not working at an optimized condition, our heart is forced to pump much more, deeper and stronger, to get the blood flow through. This puts undue stress on our heart on a chronic basis (...) What happens inside your body when you shift the temperature from warm to cold is that all the little muscles in your vascular system begin to awaken. They close up and then open, close up and open, and this repetitive process establishes the vascular muscle tone that, with repeated exposure, develops into its optimal condition.” [12(p33).]

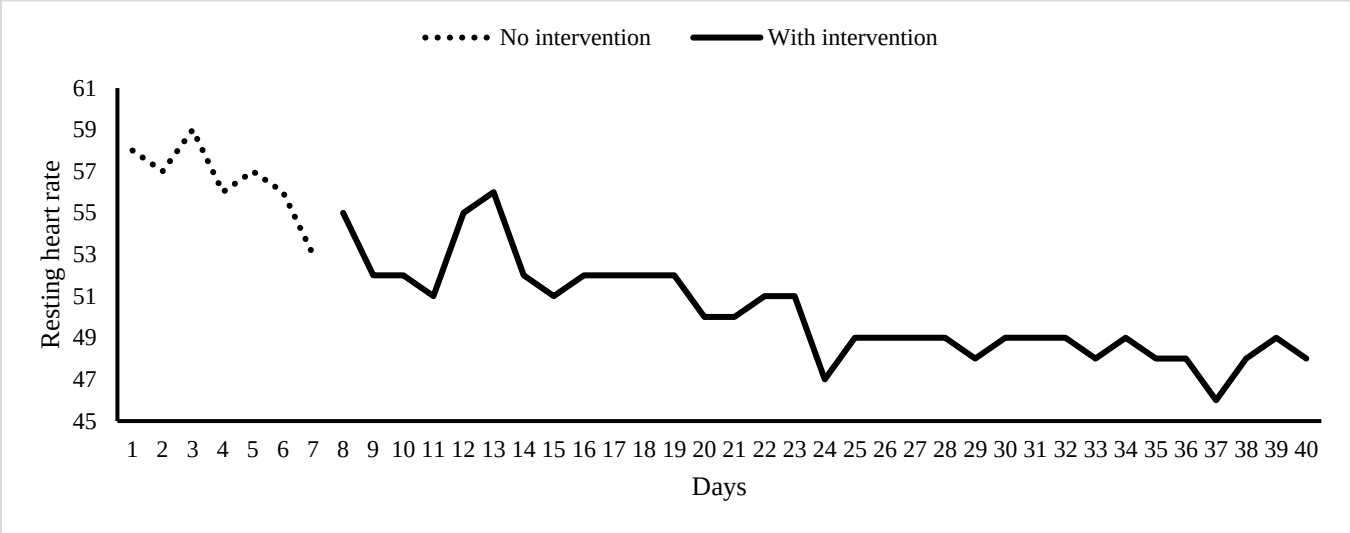

Figure 1: Resting heart rate; baseline in comparison with intervention period

Is there any data available to confirm his theory? Wim Hof is most likely referring to tone of the smooth muscle in the tunica media, which regulation causes either vasoconstriction or vasodilation [17]. Dilation of arteries and arterioles leads to an immediate decrease in arterial blood pressure and heart rate [18], and it has been shown cold water immersion results in rapid cutaneous vasoconstriction [19]. However, this acute vasoconstriction has only been showed in cold water immersion, there are no recent studies if this is also the case while cold showering. Also, whether this acute vasoconstriction also results in chronic reduction of muscle tone in the tunica media (resulting ultimately in a lower workload of the heart, thus lowering the RHR), has never been researched while this paper is published.

3.1 Limitations

First off all, this N1 study is by definition limited to a single participant, which must be kept in mind when interpreting the results.

Second, for the RHR measures, there are some sidenotes that must be noticed for this variable. That is, that heart rate is modifiable under the influence of many cofactors. For example age, gender, race, genetic factors, but also cofactors that may vary by the participant each day such as blood pressure, blood lipid, blood glucose, physical activity, smoking and alcohol [20]. It was therefore needed, to get a precise measurement of the heartrate, to develop a protocol in which deterring influence by cofactors was the goal. An example of this was by measuring at a standard time in the day, and not adjusting smoking behaviour during the measurement period in comparison with the baseline measurement period. This was recorded accurately, to only try to measure influences of the WHM training program on the RHR.

Third, it is important to scrutinize the generalization of this study. The WHM training program as described above consists of 3 elements; breathing techniques, meditation and cold exposure. The effects of these techniques have been described in this study in the context of the effects on the cardiovascular system, and has shown that it lowers the RHR after 33 days of practicing the training method. The participant in this study had no mental or physical health problems while conducting the WHM training program. However, there are indications of potential hazards for other individuals. There have been cases of participants fainting while performing the breathing exercises [21], so these exercises must always be performed in a safe environment, as Wim Hof suggests [12]. Secondly, with regard to meditation, a recent meta-analysis by Farias et al [22] demonstrated that the occurrence of neuro-cognitive, psychiatric or somatic side effects during or after meditation practice is not uncommon (8.3% (95% CI 0.05-0.12)). It can also occur in individuals who have no history of mental health problems. Care must also be taken, particularly for cardiac patients, when practicing cold exposure. Previous investigations on the short-term effects of cold exposure have shown increases of cortisol and norepinephrine concentrations [23], which results in increased heart rate, blood pressure, and stroke volume [24]. This increases the oxygen demand of the heart [25], which can provoke symptoms in angina pectoris patients [26].

When performing cold exposures more frequently, this could lead to a reduction of the cardio-respiratory responses of an individual [27,28]. However, more investigations on specifically cold showers are recommended, as proposed on page 5.

3.2 Recommendations

This study showed that the RHR was significantly reduced in this participant thanks to the WHM training programme. As described, there is increasing evidence in the literature that RHR is a predictor of CVD.

A possible opportunity for future studies would be to study a population with CVD and to follow them for a longer period of time with the WHM as an intervention. In optimal form, this could be done in a randomized controlled trial study, in which the WHM training programme is compared with another intervention in the field of CVD. However, the possible risks described in the previous section (especially for heart patients) should be taken into account. Besides this, for the physiological field, a possible opportunity for more research on specific cold exposure (in the form of cold showers) and the chronic effect on vascular muscle tone can be recommended.

References

[1] WHO. Definition of cardiovascular diseases. euro.who.int Web site. https://www.euro.who.int/en/health-topics/noncommunicable-diseases/cardiovascular-diseases/cardiovascular-diseases2/definition-of-cardiovascular-diseases. Accessed Mar 27, 2021.
[2] Nielen MMJ. Hart- en vaatziekten, cijfers en context, huidige situatie. https://www.volksgezondheidenzorg.info/ Web site. https://www.volksgezondheidenzorg.info/onderwerp/hart-en-vaatziekten/cijfers-context/huidige-situatie#node-nieuwe-gevallen-hart-en-vaatziekten-huisartsenpraktijk. Updated 2020.
[3] Nederlands Huisartsen Genootschap. NHG-standaard cardiovasculair risicomanagement -pagina 1 NHG-standaard cardiovasculair risicomanagement (M84). *4.0*. 2015.
[4] Ministerie van Volksgezondheid, Welzijn en Sport, Gezondheidsraad. Samenvatting beweegrichtlijnen 2017. . 2017. https://www.gezondheidsraad.nl/documenten/adviezen/2017/08/22/beweegrichtlijnen-2017. Accessed Apr 29, 2021.
[5] Statistiek, Centraal Bureau voor de. Leefstijl en (preventief) gezondheidsonderzoek; persoonskenmerken. Centraal Bureau voor de Statistiek Web site. http://www.cbs.nl/nl-nl/cijfers/detail/83021NED?dl=36FC6. Updated 2015. Accessed Apr 30, 2021.
[6] Definition of heart rate - NCI dictionary of cancer terms - national cancer institute. https://www.cancer.gov/publications/dictionaries/cancer-terms/def/heart-rate. Updated 2011. Accessed Apr 3, 2021.
[7] Palatini P, Julius S. Elevated heart rate: A major risk factor for cardiovascular disease. *Clin Exp Hypertens*. 2004;26(7-8):637-644. Accessed Apr 3, 2021. doi: 10.1081/ceh-200031959.
[8] Arnold JM, Fitchett DH, Howlett JG, Lonn EM, Tardif J. Resting heart rate: A modifiable prognostic indicator of cardiovascular risk and outcomes? *Canadian journal of cardiology*. 2008;24(Suppl A):3A-8A. https://explore.openaire.eu/search/publication?articleId=od267::d749318d176c853b7f387923605109f6.
[9] Lundahl B, Moleni T, Burke BL, et al. Motivational interviewing in medical care settings: A systematic review and meta-analysis of randomized controlled trials. *Patient Educ Couns*. 2013;93(2):157-168. Accessed May 1, 2021. doi: 10.1016/j.pec.2013.07.012.
[10] O'Halloran PD, Blackstock F, Shields N, et al. Motivational interviewing to increase physical activity in people with chronic health conditions: A systematic review and meta-analysis. *Clin Rehabil*. 2014;28(12):1159-1171. Accessed Apr 30, 2021. doi: 10.1177/0269215514536210.
[11] The iceman breekt weer record. *AD.nl*. 18-11- 2011. Available from: https://www.ad.nl/buitenland/the-iceman-breekt-weer-record~af501b6e/. Accessed Mar 27, 2021.
[12] Hof W. *Activate your full human potential.* ; 2020.
[13] Kox M, van Eijk LT, Zwaag J, et al. Voluntary activation of the sympathetic nervous system and attenuation of the innate immune response in humans. *PNAS*. 2014;111(20):7379-7384. Accessed Mar 27, 2021.
[14] Muzik O, Reilly KT, Diwadkar VA. "Brain over body"-A study on the willful regulation of autonomic function during cold exposure. *Neuroimage*. 2018;172:632-641. Accessed Mar 28, 2021. doi: 10.1016/j.neuroimage.2018.01.067.
[15] Zwaag J, Ter Horst R, Blaženović I, et al. Involvement of lactate and pyruvate in the anti-inflammatory effects exerted by voluntary activation of the sympathetic nervous system. *Metabolites*. 2020;10(4). Accessed Mar 28, 2021. doi: 10.3390/metabo10040148.
[16] Losa-Iglesias ME, Becerro-de-Bengoa-Vallejo R, Becerro-de-Bengoa-Losa KR. Reliability and concurrent validity of a peripheral pulse oximeter and health–app system for the quantification of heart rate in healthy adults. *Health Informatics J*. 2016;22(2):151-159. https://doi.org/10.1177/1460458214540909. Accessed Apr 3, 2021. doi: 10.1177/1460458214540909.
[17] Marieb, Hoehn. The cardiovascular system: Blood vessels. In: *Human anatomy physiology*. Pearson; 2018:721. https://www.pearson.com/nl/en_NL/higher-education/subject-catalogue/biology/Human-anatomy-physiology.html. Accessed May 6, 2021.
[18] Siddiqui A. Effects of vasodilation and arterial resistance on cardiac output. *Journal of Clinical & Experimental Cardiology*. 2011;02(11):undefined-undefined. https://www.mendeley.com/catalogue/d864d1e0-1180-3e78-95d3-770167abfc4b/. Accessed May 6, 2021.
[19] Ihsan M, Watson G, Abbiss CR. What are the physiological mechanisms for post-exercise cold water immersion in the recovery from prolonged endurance and intermittent exercise? *Sports Med*. 2016;46(8):1095-1109. Accessed May 6, 2021. doi: 10.1007/s40279-016-0483-3.
[20] Valentini M, Parati G. Variables influencing heart rate. *Prog Cardiovasc Dis*. 2009;52(1):11-19. Accessed Apr 3, 2021. doi: 10.1016/j.pcad.2009.05.004.
[21] Allen J. *Characteristics of users and reported effects of the wim hof method.* University of Twente; 2018.
[22] Farias M, Maraldi E, Wallenkampf KC, Lucchetti G. Adverse events in meditation practices and meditation-based therapies: A systematic review. *Acta Psychiatr Scand*. 2020;142(5):374-393. Accessed May 5, 2021. doi: 10.1111/acps.13225.
[23] Srámek P, Simecková M, Janský L, Savlíková J, Vybíral S. Human physiological responses to immersion into water of different

temperatures. *Eur J Appl Physiol*. 2000;81(5):436-442. Accessed May 2, 2021. doi: 10.1007/s004210050065.
[24] Cardiovascular endocrinology:: Shared pathways and clinical crossroads. In: Fonseca V, ed. Humana Press; 2009:12. https://www.springer.com/gp/book/9781588298508. Accessed May 3, 2021.
[25] Boyette LC, Manna B. Physiology, myocardial oxygen demand. In: *StatPearls.* Treasure Island (FL): StatPearls Publishing; 2021. http://www.ncbi.nlm.nih.gov/books/NBK499897/. Accessed May 4, 2021.
[26] NHG-werkgroep. NHG-standaard stabiele angina pectoris (M43). *4.0*. 2019:8.
[27] Eglin CM, Tipton MJ. Repeated cold showers as a method of habituating humans to the initial responses to cold water immersion. *Eur J Appl Physiol*. 2005;93(5-6):624-629. Accessed May 4, 2021. doi: 10.1007/s00421-004-1239-6.
[28] Tipton MJ, Golden FS, Higenbottam C, Mekjavic IB, Eglin CM. Temperature dependence of habituation of the initial responses to cold-water immersion. *Eur J Appl Physiol Occup Physiol*. 1998;78(3):253-257. Accessed May 4, 2021. doi: 10.1007/s004210050416.