

ME/CFS research for heart rate monitoring

This is a live document written by Angela Flack. Please do not distribute a saved version, use the link to share. This document accompanies The Ultimate Guide To Heart Rate Monitoring—substantial updates will be applied to it rather than here—and the Facebook group <https://m.facebook.com/groups/1511910682235160>

The research on ME/CFS specifically indicates that it is the aerobic system which is broken. Any aerobic activity (outside of a person's safe activity level) can cause harm, and can be difficult to reverse.

This includes

- ~ Pathologically low aerobic threshold that drops lower following exertion
- ~ lack of aerobic recovery in the days following exertion (can take 12-14 days)
- ~ excess lactate in the blood and brain
- ~ impaired oxygen extraction
- ~ low vo2max
- ~ low workload at AT, etc

This is in addition to documented neuroinflammation in the brain, gut permeability and inflammation following exertion, cognitive impairment, etc.

Published research studies & summaries below. This list is not exhaustive; research in this area (beyond the foundational knowledge established 2010-2015) is expanding rapidly and new studies are being published regularly. Follow on Facebook for updates:
<https://www.facebook.com/holisticcfs/>

Original published guidelines for heart rate monitoring (2010):

'Conceptual Model for Physical Therapist Management of Chronic Fatigue Syndrome/Myalgic Encephalomyelitis' (Davenport 2010)

'Optimal functioning for people with CFS/ME first depends on the achievement of a level of tissue stress that corresponds to symptom and functional maintenance. This objective will require the implementation of strategies that focus on pacing self-management to promote energy conservation and rest. After maintenance is achieved, physical stress must be provided in a manner that results in improved stress tolerance... Our experience has been that an approach beginning with therapeutic activities and exercises that avoid excessive use of the impaired aerobic system also is promising because it may mitigate the subsequent functional impairments associated with PEM. This approach involves short-duration exercises that are completed at intensities below an estimated anaerobic threshold (AT). After anaerobic activities are initiated without symptom exacerbation, progression to graded aerobic exercise can be undertaken.'

This is why symptoms are tracked alongside heart rate metrics

The references for this paper include an extended list of studies (now mostly outdated).
<https://academic.oup.com/ptj/article/90/4/602/2888236>

The below links show that ME/CFS is not caused by deconditioning.

My doctor recommended CBT & GET: what do I do? Visit this page:

<https://holisticcfs.wordpress.com/my-doctor-recommended-cbt-get-what-do-i-do/>

Research

Studies are listed in order of relevance and significance, not by date.

Format is [year of publication] name of article [key relevant info] [study link](#) further notes

[2011]

Diminished Cardiopulmonary Capacity During Post-Exertional Malaise [vo2max & AT differences in patients show up day 2 only]

https://www.tandfonline.com/doi/abs/10.1300/J092v14n02_07

[2014] Inability of myalgic encephalomyelitis/chronic fatigue syndrome patients to reproduce VO2peak indicates functional impairment

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4004422/pdf/1479-5876-12-104.pdf>

[Dec 2018] Peak Oxygen Uptake in Chronic Fatigue Syndrome/Myalgic Encephalomyelitis: A Meta-Analysis. [reviews 32 studies; 'Synthesis of the available evidence indicates that CFS/ME patients have a substantially reduced VO2peak compared to controls].

<https://www.ncbi.nlm.nih.gov/pubmed/30557887/>

[2017]

MS vs MECFS CPET NZ Study: MS Patients can replicate but ME/CFS patients cannot

<https://onlinelibrary.wiley.com/doi/abs/10.1111/cpf.12460> [paywalled]

Discussion:

<http://www.scoop.co.nz/stories/GE1705/S00067/distinguishing-chronic-fatigue-syndrome.htm>

[2019] Reproducibility of Measurements Obtained During Cardiopulmonary Exercise Testing in Individuals With Fatiguing Health Conditions

A Case Series [MS & HIV could reproduce, ME couldnt; paywall]

https://journals.lww.com/cptj/Fulltext/2019/10000/Reproducibility_of_Measurements_Obtained_During.4.aspx

[2020] Two-Day Cardiopulmonary Exercise Testing in Females with a Severe Grade of Myalgic Encephalomyelitis/Chronic Fatigue Syndrome: Comparison with Patients with Mild and Moderate Disease. [deterioration in peak workload from day-1 to day-2 is largest in the severe ME/CFS patient group]

https://www.mdpi.com/2227-9032/8/3/192/htm?fbclid=IwAR1tMc76XE6kEgqO_tbbVX5raW7Fgojr_e0cdBeLbDMVzn0J9WuOtvNsbh8

[2018] Cardiopulmonary Exercise Test Methodology for Assessing Exertion Intolerance in Myalgic Encephalomyelitis/Chronic Fatigue Syndrome [calibration needs to be specific]

<https://www.frontiersin.org/articles/10.3389/fped.2018.00242/>

[2014]

Decreased oxygen extraction during cardiopulmonary exercise test in patients with chronic fatigue syndrome. [this research is since expanded upon with invasive CPETs]

<https://www.ncbi.nlm.nih.gov/pubmed/24456560/>

PDF

<https://translational-medicine.biomedcentral.com/track/pdf/10.1186/1479-5876-12-20?site=translational-medicine.biomedcentral.com>

[2019] Orthostatic intolerance in chronic fatigue syndrome [2 day CPET; 'exercise caused an increase in OI symptoms in 22/39 CFS subjects'.. 'autonomic dysfunction, neurological issues, and vestibular mechanisms are related to elevated orthostatic symptoms...ability in symptoms that is made worse by exertion may distinguish CFS']

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6547462/>

[2016] Variability of postural orthostatic tachycardia in patients with myalgic encephalomyelitis and orthostatic intolerance [Average of 63->103 good day, 77->114 bad day] <https://link.springer.com/article/10.1007/s00380-015-0744-3>

[2009]

Cardiac function fluctuates during exacerbation and remission in young adults with chronic fatigue syndrome and "small heart". [Heart rate was significantly lower during remission than during exacerbation; PEM 71 ± 9 VS 63 ± 6 bpm]

<https://www.ncbi.nlm.nih.gov/pubmed/19632517/>

Note: 8bpm is the range of difference on average. This is why 5-10% accuracy is not good enough for heart rate monitoring.

[2003] Heart rate monitoring: applications and limitations. [increased resting HR in overtrained individuals, but not in overreaching (less serious). 'Sleeping HR appears to be increased when individuals are overreached. It has been suggested that sleeping HR is a more reliable measure since it is less likely to be affected by confounding variables']

https://www.researchgate.net/publication/10746534_Heart_rate_monitoring_applications_and_limitations

[2019] Chronotropic Intolerance: An Overlooked Determinant of Symptoms and Activity Limitation in Myalgic Encephalomyelitis/Chronic Fatigue Syndrome? [overview article; controls 95% predicted max, patients 82% predicted max]

<https://www.frontiersin.org/articles/10.3389/fped.2019.00082/full>

[2015] Deviant Cellular and Physiological Responses to Exercise in Myalgic Encephalomyelitis and Chronic Fatigue Syndrome [comprehensive overview of research, explicitly states not exercise avoidance or deconditioning; PEM causes pain; slow twitch muscles]

https://www.researchgate.net/publication/284633632_Deviant_Cellular_and_Physiological_Responses_to_Exercise_in_Myalgic_Encephalomyelitis_and_Chronic_Fatigue_Syndrome_Frank_NM_Twisk1_Keith_J_Geraghty2

[2017]

Neural consequences of post-exertion malaise in Myalgic Encephalomyelitis/Chronic Fatigue Syndrome [submax] <http://www.sciencedirect.com/science/article/pii/S088915911730051X>

[2019] Abnormal blood lactate accumulation during repeated exercise testing in myalgic encephalomyelitis/chronic fatigue syndrome

<https://physoc.onlinelibrary.wiley.com/doi/full/10.14814/phy2.14138>

[2019] Elevated blood lactate in resting conditions correlate with post-exertional malaise severity in patients with Myalgic encephalomyelitis/Chronic fatigue syndrome

<https://www.nature.com/articles/s41598-019-55473-4>

[2019] Unexplained exertional intolerance associated with impaired systemic oxygen extraction [exercise limitation is due only to systemic oxygen extraction, due to either an intrinsic abnormality of skeletal muscle mitochondrion, limb muscle microcirculatory dysregulation, or hyperventilation and left shift the oxyhemoglobin dissociation curve]

https://link.springer.com/article/10.1007%2Fs00421-019-04222-6?fbclid=IwAR1kSSCdLXW_P6MqhBI3x1AJxHR57iq_PnsL23S50R6NTBzAAAd1AmOrn4SQ

Note: This is not a ME/CFS specific article, however Systrom is now working on it:

[2019] Pathophysiology and treatment of exertional intolerance in MECFS

<https://youtu.be/az-1OAYnH2k>

[2021] Deconditioning does not explain orthostatic intolerance in ME/CFS (myalgic encephalomyelitis/chronic fatigue syndrome)

<https://translational-medicine.biomedcentral.com/articles/10.1186/s12967-021-02819-0>

[2016, june] Reduced cardiac volumes in chronic fatigue syndrome associate with plasma volume but not length of disease: a cohort study [ME/CFS is Not deconditioning]:

<http://openheart.bmj.com/content/3/1/e000381>

[Nov 2018] The Abnormal Cardiac Index and Stroke Volume Index Changes During a Normal Tilt Table Test in ME/CFS Patients Compared to Healthy Volunteers, are Not Related to Deconditioning [replication and larger study]

<https://www.gavinpublishers.com/articles/Research-Article/Journal-of-Thrombosis-and-Circulation/The-Abnormal-Cardiac-Index-and-Stroke-Volume-Index-Changes-During-a-Normal-Tilt-Table-Test-in-ME-CFS-Patients-Compared-to-Healthy-Volunteers-are-Not-Related-to-Deconditioning>

Overview summary:

<https://www.meassociation.org.uk/wp-content/uploads/MEA-Review-Abnormal-cardiac-changes-in-MECFS-not-due-to-deconditioning-23.11.18.pdf>

[2020] Cerebral blood flow is reduced in ME/CFS during head-up tilt testing even in the absence of hypotension or tachycardia: a quantitative, controlled study using Doppler echography [orthostatic intolerance affects patients even without POTS]

<https://www.sciencedirect.com/.../pii/S2467981X20300044>

[2019] Orthostatic intolerance in chronic fatigue syndrome [subsets, constant POTS, no POTS, POTS only with PEM] <https://link.springer.com/article/10.1186/s12967-019-1935-y>

[2015] The Aerobic Energy Production and the Lactic Acid Excretion are both Impeded in Myalgic Encephalomyelitis/Chronic Fatigue Syndrome
https://www.researchgate.net/publication/282133390_The_Aerobic_Energy_Production_and_the_Lactic_Acid_Excretion_are_both_Impeded_in_Myalgic_EncephalomyelitisChronic_Fatigue_Syndrome

[2017, Nov] Elevated brain natriuretic peptide levels in chronic fatigue syndrome associate with cardiac dysfunction: a case control study [cardiac volumes]
<http://openheart.bmj.com/content/openhrt/4/2/e000697.full.pdf>

[2016, May, letter to editor] Postural tachycardia syndrome is not caused by deconditioning
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5019095/>

[2001] Is physical deconditioning a perpetuating factor in chronic fatigue syndrome? A controlled study on maximal exercise performance and relations with fatigue, impairment and physical activity. [CPET; shows it is not]
<https://www.ncbi.nlm.nih.gov/pubmed/11200949/>

[2004] Decrease in heart rate variability with overtraining: assessment by the Poincaré plot analysis. [Overtrained athletes had a marked predominance of sympathetic activity regardless of the position] <https://www.ncbi.nlm.nih.gov/pubmed/14717743/>

[2018] POTS subtypes [mainly neuropathic, some hyperadrenergic or deconditioned]
<http://journals.sagepub.com/doi/10.1177/2515816318773774>

[2017, dec] Autonomic nervous system function, activity patterns, and sleep after physical or cognitive challenge in people with chronic fatigue syndrome [Nocturnal parasympathetic activity was reduced post-challenge.]
<https://www.sciencedirect.com/science/article/pii/S0022399917304981>

[2019] Editorial, Autonomic markers, chronic fatigue syndrome, and post-exertion states. [paywalled; Reduced HRV a sensitive autonomic indicator of post-exertional worsening and a correlate of activity and fatigue]
<https://www.sciencedirect.com/science/article/abs/pii/S0022399919309055>

[2019] Parasympathetic activity is reduced during slow-wave sleep, but not resting wakefulness, in patients with chronic fatigue syndrome
<https://www.ncbi.nlm.nih.gov/m/pubmed/31771749/>

Note: this is why sleep data is important

Secondary research

Earlier research used Oxford and Fukuda mixed case definitions and so found mixed results. Newer research uses ICC, CCC and SEID criteria which require PEM.

Unsupportive literature is included in this section, critique is included [in notes]

Research of the wider context or from secondary sources is also included in this section.

[1998] Physical activity before and after exercise in women with chronic fatigue syndrome. [PEM may last 12-14 days]

<https://academic.oup.com/qjmed/article-abstract/91/7/465/1598063>

[2000] Exercise Capacity in Chronic Fatigue Syndrome [higher RHR lower exercise HR, autonomic disturbances]

<https://jamanetwork.com/journals/jamainternalmedicine/fullarticle/485564>

[2007] Can submaximal exercise variables predict peak exercise performance in women with chronic fatigue syndrome? [within subject variability]

<https://www.sciencedirect.com/science/article/pii/S0188440906004048>

[2003] Complement activation in a model of chronic fatigue syndrome [Exercise challenge induced significant increases of the complement split product C4a, at 6 hours after exercise—just one example of post exercise changes]

<https://www.ncbi.nlm.nih.gov/pubmed/12897748/>

[2018] Training Prescription Guided by Heart Rate Variability in Cycling [improved peak power and power at VT]. <https://www.ncbi.nlm.nih.gov/pubmed/29809080/>

[2012] ME ASSOCIATION 294 page patient survey on CBT and GET

<https://www.meassociation.org.uk/wp-content/uploads/2015-ME-Association-Illness-Management-Report-No-decisions-about-me-without-me-30.05.15.pdf>

Meaction summary of patient survey

<https://www.meaction.net/2015/05/29/me-associations-mecfs-illness-management-survey-results-cbt-get-pacing/>

Grounding improves HRV; Emotional stress, heart rate variability, grounding, and improved autonomic tone: clinical applications

https://www.researchgate.net/publication/288949293_Emotional_stress_heart_rate_variability_grounding_and_improved_autonomic_tone_clinical_applications

[2005] Circadian rhythm of spectral indices of heart rate variability in healthy subjects [HRV metrics in normal people. HF showed circadian pattern with the greatest night values and LF/HF with the smallest night values. Peaks of hourly LF were found between 5 and 9am and between 4 and 6pm. The smallest LF was between 11pm and 3am. Hourly HF peaked between 11pm and 5am. The smallest HF was observed between midday and 2pm. LF/HF peaked between 6 and 9am as well as between 4 and 6pm with the smallest values between midnight and 5am]. <https://pubmed.ncbi.nlm.nih.gov/16003709/>

[2004] Physiological responses during a submaximal cycle test in chronic fatigue syndrome
[poor source: psychologisation, concluded avoidance];
<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.572.1991&rep=rep1&type=pdf>

[2008] Can exercise limits prevent post-exertional malaise in chronic fatigue syndrome? An uncontrolled clinical trial <http://journals.sagepub.com/doi/abs/10.1177/0269215507084410>

[2006] How relevant are exercise capacity measures for evaluating treatment effects in chronic fatigue syndrome? Results from a prospective, multidisciplinary outcome study.
<http://journals.sagepub.com/doi/abs/10.1191/0269215506cr914oa>

[poor source: fukuda, GET & CPET not associated with functional improvement/QOL, drop out?]

[2003] Subclassifying Chronic Fatigue Syndrome through Exercise Testing [by severity]
<http://emerge.org.au/wp-content/uploads/2014/11/Vanness-J.-M.-et-al.-Subclassifying-chronic-fatigue-syndrome-through-exercise-testing.-Med-Sci-Sports-Exerc-2003-356-908-913.pdf>

[2004] Randomised controlled trial of graded exercise in chronic fatigue syndrome.
<http://search.proquest.com/openview/eaed7a6932f120b42fa8c09e4c492923/1?pq-origsite=scholar&cbl=40810> [GET & CPet, depressive, no change in activity, drop out]

[1996] Decreased vagal power during treadmill walking in patients with chronic fatigue syndrome <https://link.springer.com/article/10.1007/BF02556303>

[2016] Tilt table test today - state of the art.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4807316/pdf/WJC-8-277.pdf>

[2017] Special issue on the PACE trial in the Journal of Health Psychology
<http://journals.sagepub.com/toc/hpqa/22/9>

Autoimmunity in POTS

<https://www.facebook.com/180205575731472/posts/565505510534808/?d=n>
<https://www.facebook.com/180205575731472/posts/565496583869034/?d=n>
<https://www.facebook.com/180205575731472/posts/538388423246517/?d=n>
<https://www.facebook.com/180205575731472/posts/507285069690186/?d=n>

Overview of b-adrenergic autoimmunity

<http://simmaronresearch.com/.../blood-vessel-crunch.../>

[2019] The Benefits of Oral Rehydration on Orthostatic Intolerance in Children with Postural Tachycardia Syndrome [oral ORS was more effective in helping POTS than IV saline or water alone] <https://pubmed.ncbi.nlm.nih.gov/31405524/>

Devices

Recommended devices:

<https://docs.google.com/spreadsheets/d/19Z-CPchaQAU3FFRRIf24h4w0y6ZQjxnTqtPr0rsWiqE>

Device accuracy

While there is some research comparing ambulatory ECG to adhesive Holter monitors, and suggesting ambulatory ECG with a standard holter compared to a adhesive monitor misses some arrhythmias, this is not at all relevant to the accuracy of the polar chest strap in comparison to watches, for a number of reasons. 1, holter monitors are the medical standard to which everything else is measured. If they are 1% imperfect, that does not justify 5-15% ranges of imperfection in watches. 2. This study is comparing totally different time frames, 1 day versus 14 days. As such, this is not at all saying that either ECG is inaccurate. Arrhythmias only go undetected because they occur infrequently, with a smaller monitor they are worn for longer and so more are detected. 3, when compared across the same time frame, the holter monitor, a standard ecg against which the polar h10 was exactly as accurate as to be expected from a medical device (a maximum of possibly 2 inconsequential arrhythmia events undetected, and zero consequential events 24/24 detected)).

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3882198/pdf/nihms532184.pdf?fbclid=IwAR0U75JiopxDslmyP0_dL4NzxGx8cotfnzJ7ZGZ4qmXzBnrsn1gtnRtT7fw

The error of consumer wearables was an average of 7.2 ± 5.4 bpm.

~ During physical activity, it was 10.2 ± 7.5 bpm. Apple Watch 4 had the lowest error (4.4 bpm).

~ At rest, error was highest for the Fitbit Charge 2 and lowest for Apple Watch 4 (7.3 and 2.7 bpm). During physical activity, the Apple Watch 4 had the lowest error (4.6 bpm)

~ The Garmin was most variable in accuracy, and the Apple Watch 4 least (as SD, 9.2 and 3.0, respectively).

~ At rest, missing data was highest for the Fitbit Charge 2 and lowest for the Apple Watch 4 (18.7 and 2.7%).

~ During physical activity missing data was highest for the Fitbit Charge 2 and unchanged for the Apple Watch

~ The rhythmic movement of walking has significantly higher errors in all devices except the Apple Watch 4

~ Typing caused errors in all devices.

~ Walking (and other activity) tended to cause reported HR to be higher than true HR, whereas typing caused the reported HR to be lower than the true HR

The research excluded a possible cause of inaccuracy being the delay between the actual heart beat and the change in blood volume at wrist, as removing lag did not improve the accuracy. In general, devices with higher cost, a more recent release date, and a larger market had higher accuracy. [However, still not as high as for chest straps].

From the study: Error in wrist-worn devices is usually due to motion artifact, which is typically caused by displacement of the PPG sensor over the skin, changes in skin deformation, blood flow dynamics, and ambient temperature. Motion artifacts may manifest as missing or false beats which result in incorrect HR calculations. Data loss occurs in watches occurs when a device is not making contact with the skin, or when the device removes data that fails internal quality control, (when there is a large motion artifact indicated by high accelerometry sensor values), it removes the data points potentially affected by the artifact).

Each round of the study protocol, included

- seated rest to measure baseline (4 min)
- paced deep breathing (1 min)
- physical activity (walking to increase HR up to 50% of the recommended maximum (5 min)
- seated rest (washout from physical activity) (~2 min), and
- a typing task (1 min).

Round 1: Empatica E4 + Apple Watch 4

Round 2: Fitbit Charge 2

Round 3: Garmin Vivosmart 3, Xiaomi Miband, and Biovotion Everion.

The electrocardiogram (ECG) patch was worn during all three rounds.

Skin tone did not correlate with accuracy.

Assessed by mean directional error (MDE, $\pm$ standard deviation (SD)) and the mean absolute error (MAE)

<https://www.nature.com/articles/s41746-020-0226-6>

This study had a very high quality and comprehensive design. Previous research is of varied quality and design, 'accuracy' can be defined very loosely (allowed error margins of 5%) or with vague metrics, or minimal sampling (once per minute) is used.

One study (running on treadmill) found the Polar H7 Chest Strap had the highest correlation with the ECG (98). This was followed by the Apple Watch III (96). The Fitbit Ionic, Garmin Vivosmart HR, and Tom Tom Spark 3 all had the same level of agreement with the ECG (89). <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6732081/>

Workwell resources

<http://www.workwellfoundation.org/resources/>

Including

Workwell against GET

<http://www.workwellfoundation.org/wp-content/uploads/2018/05/MECFs-GET-Letter-to-Health-Care-Providers-v4-30-2.pdf>

Stacy Stevens 2015 talk with tips to help prevent crashes:

<https://www.youtube.com/watch?v=XFz4CK0Js1M>

Mark VanNess videos explaining metabolic, cardiovascular, and pulmonary system impairment.

(Summary & transcript at holisticcfs blog)

<https://www.youtube.com/watch?v=FXN6f53ba6k&>

<https://www.youtube.com/watch?v=7BceGgEdMpA>

Short explanation of the Workwell 2 day CPET test

<https://www.youtube.com/watch?v=kCO3pAbSq3I>

http://www.youtube.com/watch?v=q_cnva7zyKM

3 Page Workwell summary (old) 'when working out doesn't work out)

<http://www.workwellfoundation.org/wp-content/uploads/2014/04/When-Working-Out-Doesnt-Work-Out.pdf>

Zone calculator

https://docs.google.com/file/d/1s-YpCotTqUHxvmPBW_WM8PBdB4uFBeVp/

Lists of links: secondary info beyond what is included in this document

Exercise: Chronological list of studies with brief summaries updated sept 2018:

<https://paradigmchange.me/me/exercise/>

Cardio abnormalities: Comprehensive list of studies with short summaries updated sept

2018 <https://paradigmchange.me/me/abnormalities-cardiac/>

Pacing CFIDS list of article links

<http://www.cfidsselfhelp.org/library/topic/Energy+Envelope+and+Pacing>

Health rising list of links (2015)

<https://www.healthrising.org/forums/resources/exercise-resource-center-for-chronic-fatigue-syndr>
[yndrome.168/](https://www.healthrising.org/forums/resources/exercise-resource-center-for-chronic-fatigue-syndr)

<https://www.healthrising.org/the-workwell-foundation-resource-page-for-chronic-fatigue-syndr>
[ome/](https://www.healthrising.org/the-workwell-foundation-resource-page-for-chronic-fatigue-syndr)

Patient experiences

'After unrest' documentary

From 13-16 minutes in—patient and doctors discussing heart rate monitoring

<https://youtu.be/5bhYYwsD8KU>

First hand account of CPET and attempting to PACE

Occupy ME exercise and heart rate

<http://occupyme.net/exercise-testing-and-results/>

Patient experience by Leela play

https://m.facebook.com/story.php?story_fbid=1398761576814379&id=100000497383171

Discussion

GET primer (Simone Eyssens)

<https://emerge.org.au/wp-content/uploads/2018/04/PEM-GET-Primer.pdf>

Dangerous exercise: The detrimental effects of exertion and orthostatic stress in Myalgic Encephalomyelitis and chronic fatigue syndrome (Frank Twisk):

<https://oatext.com/pdf/PMRR-2-134.pdf>

Quotes: <http://paradigmchange.me/exercise-quotes/>

<http://one1cent7.wix.com/from-me-back-to-me#lcpet-testing/c1e6t>

What is PEM:

<https://healthunlocked.com/ramsaysdisease/posts/131728315/post-exertional-malaise>

Pacing against numbers

<http://www.cfidsselfhelp.org/library/pacing-numbers-using-your-heart-rate-to-stay-inside-energy-envelope>

An analysis of Dutch hallmark studies confirms the outcome of the PACE trial: Cognitive behaviour therapy with a graded activity protocol is not effective for chronic fatigue syndrome and Myalgic Encephalomyelitis.

<http://www.hetalternatief.org/Summary%20NKCV%20GMO%202018.pdf>

Duplicate contained within other links:

Heart Rate Variability (HRV) An Underused ME/CFS/FM Management Tool: PT II –

Surveying the Landscape

<https://www.healthrising.org/forums/resources/heart-rate-variability-hrv-an-underused-me-cfs-fm-management-tool-pt-ii-%E2%80%93-surveying-the-landscape.457/>

HRV: a deep primer by Marco from HRV4Training

<https://www.hrv4training.com/blog/heart-rate-variability-a-primer>

Overtraining summary YouTube video- **psych therapies- no objective measures**

<https://www.youtube.com/watch?v=bPxhzMtKDnQ>

General information

Information on deconditioning

Resting heart rate increases 3-15 beats in first few weeks then plateaus

Note: content may be distressing

http://aging.ufl.edu/files/2011/01/deconditioning_campbell.pdf

Dr lam tachy & adrenal fatigue brilliant article very detailed included treatment and YouTube video

<https://www.drlam.com/blog/tachycardia-symptoms-pots-afs-part-1/10836/>

SDNN on Apple Watch is equivalent to rmssd

<https://www.hrv4training.com/blog/heart-rate-variability-hrv-features-can-we-use-sdnn-instead-of-rmssd-a-data-driven-perspective-on-short-term-variability-analysis>

41 page document on HRV (not specific to MECFS)

http://medi-core.com/download/HRV_clinical_manual_ver3.0.pdf

Low HRV in clinical burnout

<https://www.sciencedirect.com/science/article/abs/pii/S016787601630681X>

Info sheet on ventilatory threshold

https://acewebcontent.azureedge.net/certifiednews/images/article/pdfs/VT_Testing.pdf

Individuals who participated in the PACE & other CBT/GET trials

Pre-'PACE': <https://www.meaction.net/2019/11/21/a-trial-of-me-elizabeths-story/>

Cardiomyopathy

<https://docs.google.com/document/d/1-72Kb14gKC3qU5lI8DElJeGliGgfpOHpUhW6eBuFw-U/>

This information may be of interest to more advanced pacers. This is not from a reputable source. It's inclusion is not an endorsement of the link content, and this link is not recommended for beginners. Read with your own discretion.

1- don't read it if you are stressed, crashed, tending towards overwhelmed, or at all in a bad place. It is slightly alarmist/worse case scenario

2- this is a theoretical construct separate to the more evidence-based HRM pacing in this group

3- no one I know of has successfully requested cardiac impedance testing

NASA lean test for POTS

<https://batemanhornecenter.org/assess-orthostatic-intolerance/>

For resources relating to ME/CFS more generally, visit the Resources Page at

<https://holisticcfs.wordpress.com/resources/>

For an overall summary of ME/CFS research, see

https://m.box.com/shared_item/https://app.box.com/s/9s4coexxtys5bnz33i6gvqqygu67ex5o