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Effects of complementary eurythmy therapy on heart rate variability

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KEYWORDS
Heart rate variability;
Eurythmy therapy;
Meditation;
Mind-body therapy;
Ergometer training;
Relaxation techniques

Summary
Background: The importance of mind-body oriented therapies in oncology has increased in recent years. Eurythmy therapy (EYT, Greek: eurythmy = harmonious rhythm) is a mind-body oriented therapy used in Anthroposophic Medicine. EYT can lead to long-term alleviation of chronic disease symptoms and improve patient quality of life. Yet, little is known about underlying physiological mechanisms.
Objective: This study aims to compare the effects of EYT and conventional ergometer training (CET) on heart rate variability (HRV).
Design: In a cross-over design, 20 healthy subjects performed two different EYT exercises and two sessions of CET. ECGs were recorded throughout these procedures. HRV was quantified by the extent of very low (VLF), low (LF) and high frequency (HF) oscillations of heart rate.
Results: VLF and LF oscillations increased during one EYT exercises when compared to rest after EYT ('B exercise', VLF: 7.65 vs. 6.57 log ms^2; LF: 8.06 vs. 6.15 log ms^2) whereas during the other EYT exercise only LF increased ('L exercise', LF: 7.19 vs. 6.25 log ms^2). HF was not affected. During CET VLF, LF and HF decreased compared to rest (VLF: 5.4 log ms^2, LF: 4.5 log ms^2, HF: 3.2 log ms^2). During rest after both EYT exercises LF/HF decreased when compared to rest after CET (0.4 and 0.5 vs. 1.4).
Conclusion: At comparable workloads, EYT stimulated HRV whereas CET attenuated HRV. The decrease of LF/HF during rest after EYT indicates an improved relaxation. These results suggest that patients may benefit from EYT in terms of HRV improvement.

Abbreviations: EYT, eurythmy therapy; CET, conventional ergometer training; ANS, autonomic nervous system; HRV, heart rate variability; VLF, very low frequency; LF, low frequency; HF, high frequency; SDNN, standard deviation of normal-to-normal RR-intervals; RSA, respiratory sinus arrhythmia.

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Introduction

In recent years, the beneficial impact of complementary therapies, such as mind-body therapies like meditation, on well-being has been investigated in chronically ill patients. Mindfulness-based stress reduction led to a decrease of sleep disturbances, mood disturbances, stress and fatigue in cancer outpatients.[1] Mind-body therapies have also been used as relaxation techniques to help patients better cope with different cancer-related symptoms such as pain and anxiety.[2]

Therapeutic eurythmy (EYT-eurythmy therapy) is a therapeutic tool of anthroposophic medicine and has been practised for 80 years.[3] It consists of specific body movements with accompanying meditative aspects. Body movements are carried out in conjunction with guided imagery. Although EYT has been applied as a complementary treatment of chronically ill patients for several decades there are only few systematic studies up to date.

The formative dynamics, sonation and articulation performed by the vocal organs during the act of pronouncing vowels and consonants comprise the basis of EYT. These characteristics of phonation are then translated into movements of the whole body for therapeutic use. Furthermore, in EYT the movements of the body are accompanied by an appropriate imagery that helps facilitate the movement. Hence, EYT combines body movements with a special kind of meditation. Apart from its indications for acute, chronic and degenerative diseases, EYT is also used to promote the development of health (salutogenesis) as well as for rehabilitative purposes. In oncology and other acute and chronic diseases treated complementary with anthroposophic medicine, EYT is frequently employed as a complementary treatment.[4]

Conceptually, the exercises in EYT make use of the assumed relationship between a person's external movements and internal physiologic functions. The movements that correspond to each vocal or consonant can be specified and modified at the organic level of the human body. EYT targets the somatic and functional level at its origin and encompasses the emotional, psychosocial and cognitive levels.

The sparse clinical documentation of EYT available consists of case reports and case series,[3,5] expert opinions and retrospective surveys but, as of yet, no controlled clinical studies.[4] Relevant aspects of EYT in practice have been evaluated as part of a prospective cohort study in Germany (Anthroposophic Medicine Outcome Study).[6] 419 patients exercised EYT for various indications including cervical syndromes, attention deficit/hyperactivity syndrome, disturbed social behavior, headaches and cancer.[7] In their concluding statement the authors found that a long-term reduction of symptoms and an improvement in quality of life was associated with anthroposophic therapies like EYT. According to the authors, these changes were not explicable by external factors such as concomitant therapies or spontaneous improvement but were likely attributable to the efficacy of EYT.

The available studies on EYT claim efficacy but provide little information on the underlying mechanisms.[7,8] Therefore, the aim of this study was to examine the effect of EYT on cardiovascular functions by measuring heart rate variability (HRV). HRV quantifies the amount of variations that can be found in the instantaneous heart rate. In healthy subjects the instantaneous heart rate shows fluctuations on different time scales, e.g. fluctuations induced by respiration (respiratory sinus arrhythmia, RSA) and fluctuations attributed to the control of blood pressure. These fluctuations may also be linked to the activity of the ANS because RSA is unequivocally linked to parasympathetic activity whereas blood pressure control is linked to both sympathetic and parasympathetic activity. Hence, HRV can be used to evaluate the adaptability of the autonomic nervous system (ANS).[9,18]

Furthermore, HRV has proven useful as a predictor of cardiovascular mortality after myocardial infarction.[10,11] In healthy subjects HRV was strongly associated with health-related quality of life.[12–14] Buchheit et al. showed that in elder people long-term physical activity was associated with higher global HRV and vagal-related indexes.[15,16] In addition, in elderly woman moderate low-energy expenditure was associated with better self-estimated overall health status and higher HRV indexes compared to peers with low low-energy expenditure. Similarly, a 3-month period of Tai Chi Chuan was found to improve not only fitness measures and health-related quality of life in elderly woman but also to improve HRV.[17]

Consequently, we asked in our study whether two different EYT exercises had an impact on HRV both during and immediately after the EYT exercise. The selected exercises include slow and marked body movements and should have an impact on cardiovascular functions. Hence, we hypothesize an increase of HRV. In contrast, the commonly used conventional ergometer training (CET) with roughly comparable physical activity (as indicated by a similar average heart rate) should show a decrease in HRV because CET only focuses on a pre-defined increase of heart rate. The increase of heart rate is accompanied by a decrease of HRV. Hence, CET was used as a control in this exploratory assessment.

Materials and methods

Subjects

20 healthy subjects (university department staff; 13 female, seven male) enrolled in the study. The average age (±standard deviation) was 42.2 ± 12.6 years and the average body mass index was $23.3 \pm 3.8\,\text{kg/m}^2$. All subjects stated that they had no history of cardiovascular diseases and did not take any medication, particularly no anti-arrhythmic medication. All participants gave their informed written consent.

EYT

Each participant performed either one of the two 30-min sessions of EYT or the accompanying CET once weekly for 4 weeks, beginning with the first EYT exercise. The first EYT exercise consisted of the 'B exercise'. The second EYT exercise consisted of the 'L exercise'. The B and L exercises were selected because they showed pronounced HRV alterations in preliminary tests. Both exercises were carried out for approximately 10 min. The B and L exercises were also embedded in other EYT exercises, because nor-

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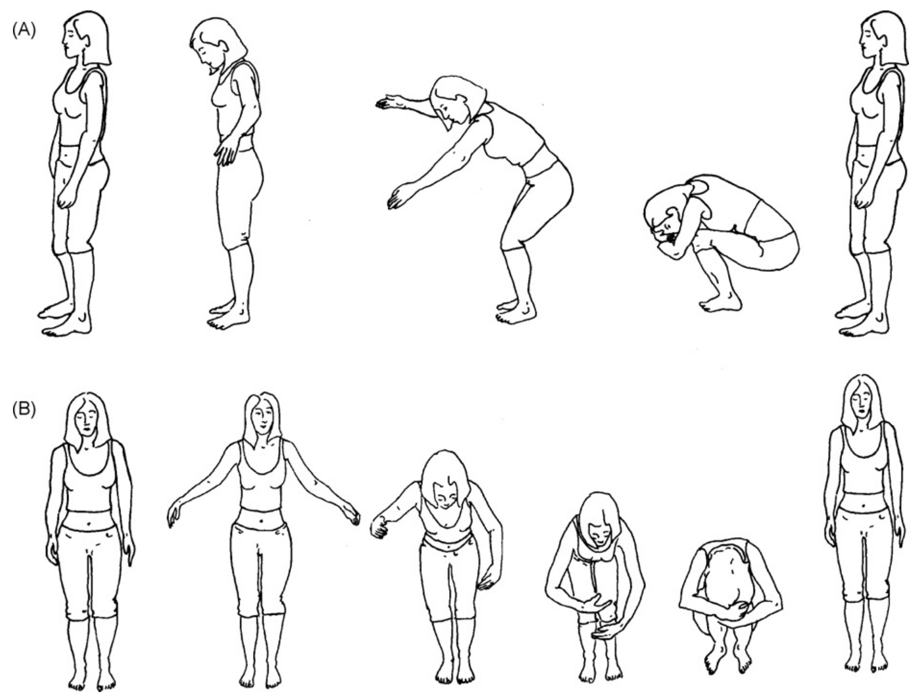

Figure 1 Succession of movements (from left to right) of the EYT 'B exercise': (a) side view and (b) frontal view.

mal 30 min EYT sessions contain a series of distinct exercises. The embedding exercises were identical for both experimental EYT sessions. Subjects rested afterward in the supine position for 15 min.

In essence, during the EYT 'B exercise,' the body moves from a standing to a squatting position and then returns to the original stance (cf. Fig. 1a and b). While moving into the squat, the chest is pulled downward until the chest touches the legs. The arms move simultaneously upward to encircle the head, which also touches the legs in the squatting position. Subsequently, the body is brought back into the vertical position. Specific images accompany the body movements (e.g. the participant is asked to center the feelings at one point while moving into the squat and to release these feelings while moving upward again). This exercise is carried out slowly, a complete cycle lasting approximately 15 s (4 cycles/min).

The EYT 'L exercise' exercise consists of a squat with the chest slightly leaned forward (Fig. 2). Note that the knees touch each other. At the same time, the arms move to form a circle when the chest reaches its lowest point. However, before squat is carried out completely, having reached approximately the halfway point, the chest is moved upward again. While lifting the chest up, the arms are also raised until the hands reach the height of the chin. Subsequently, the arms are lowered and the knees cease to touch. As in the other EYT exercise, specific mental images accompany the movements of the body (e.g. imagine to take hold of something in the squat position, lift it upward and release it into the sky with outstretched arms). This exercise is performed slowly. Thus one complete cycle takes approximately 10 s (6 cycles/min).

CET

CET was carried out on a bicycle ergometer at approximately the same heart rate as to the preceding EYT exercise. It lasted approximately 30 min and was followed by a 15 min resting period in the supine position.

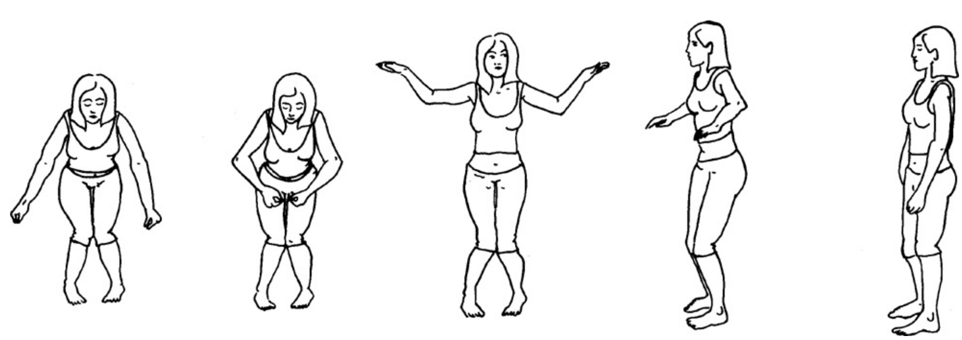

Figure 2 Succession of movements (from left to right) of the EYT 'L exercise'.

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Table 1 Hart rate parametrs of EYT ''B'' exercise.

	'B exercise'	$rest_{EYT}$	Ergometer	$rest_{Ergom.}$
Heart rate (bpm)	$97.8^{***,###} \pm 13.1$	$70.3^{§§§} \pm 8.9$	$111.7^{###} \pm 23.7$	81.5 ± 13.2
SDNN (ms)	$75^{***,###} \pm 18$	44 ± 21	$20^{###} \pm 8$	51 ± 27
log VLF (log ms^2)	$7.65^{***,###} \pm 0.55$	6.57 ± 0.69	$5.39^{###} \pm 0.67$	6.78 ± 0.92
log LF (log ms^2)	$8.06^{***,###} \pm 0.72$	6.15 ± 0.77	$4.41^{###} \pm 1.25$	6.63 ± 1.11
log HF (log ms^2)	$6.14^{***} \pm 0.78$	$5.77^{§} \pm 1.03$	$3.09^{###} \pm 1.26$	5.19 ± 1.35
log LF/HF	$1.92^{**,###} \pm 0.53$	$0.38^{§§§} \pm 0.62$	1.33 ± 0.65	1.44 ± 0.67

Average and standard deviation of HRV parameters for the EYT 'B exercise' and the accompanying ergometer training. VLF, LF, HF and LF/HF were log-transformed (indicated by the prefix 'log') due to their skewed distributions.
** $p < 0.01$ vs. ergometer.
*** $p < 0.001$ vs. ergometer.
§ $p < 0.05$ vs. $rest_{Ergom}$.
§§§ $p < 0.001$ vs. $rest_{Ergom}$.
$p < 0.001$ vs. accompanying rest.

Heart rate variability

A 1-channel Holter electrocardiogram (ECG, standard lead) was recorded during all exercise sessions (Medikorder MK3, TOM-Medical, Graz, Austria). The sampling rate of the ECG was 4096 Hz. Hence, the device's internal identification of R-peaks of the heartbeats had a temporal precision of <1 ms. The ECG trace was recorded at a sampling rate of 256 Hz. The times of the automatically identified R-peaks were controlled and the timings of the R-peaks were corrected if necessary (e.g. in case of artefacts). The times of the R-peaks served as the basis for further calculations. The data were further analyzed using Matlab (The Mathworks, Natick, MA, USA).

The normal-to-normal intervals between successive R-peaks served as the basis for the analysis of heart rate variations. Mean heart rate (HR) of normal-to-normal heartbeats and the accompanying standard deviation (SDNN) were calculated as basic time domain parameters. The RR-tachogram, i.e. the sequence of times between successive R-peaks, was re-sampled at a rate of 4 Hz and a Hanning window was applied to this time series. The extent of very low, low and high frequency oscillations of heart rate variations (VLF: <0.04 Hz, LF: 0.04—0.15 Hz, HF: 0.15—0.4 Hz) and the ratio, LF/HF, were then calculated via the fast Fourier transformation as parameters in the frequency domain.[18]

Statistics

Each period of exercise und rest was divided into subsequent 5-min epochs. Each 5-min epoch of the recording was then quantified as follows: mean heart rate (HR), SDNN, VLF, LF, HF and LF/HF. The values of VLF, LF, HF and LF/HF were transformed by taking the natural logarithm (indicated by the prefix 'log' in Tables 1 and 2) because they had skewed distributions. Student's *t*-test with adjusted *p*-values for multiple comparisons (Bonferroni correction) was used to calculate the probability of differences between EYT and the respective CET as well as the differences between the exercises (YET, CET) and the subsequent resting periods. A *p*-value <0.05 was considered statistically significant.

Results

HRV during and after the EYT B exercise

During the 'B exercise' the average heart rate was 97 bpm and decreased to 70 bpm during rest after the exercise

Table 2 Hart rate parameters of EYT ''L'' exercise.

	'L exercise'	$rest_{EYT}$	Ergometer	$rest_{Ergom.}$
Heart rate (bpm)	$98.8^{***,###} \pm 12.6$	$69.9^{§§§} \pm 7.8$	$107.5^{###} \pm 15.9$	78.8 ± 11.1
SDNN (ms)	$52^{***,#} \pm 13$	$44^{§§} \pm 22$	$19^{###} \pm 9$	47 ± 16
log VLF (log ms^2)	$6.94^{***,#} \pm 0.52$	6.51 ± 0.70	$5.17^{###} \pm 0.76$	6.59 ± 0.83
log LF (log ms^2)	$7.19^{***,##} \pm 0.67$	6.25 ± 0.84	$4.54^{###} \pm 1.12$	6.67 ± 0.87
log HF (log ms^2)	$5.33^{***} \pm 0.95$	5.75 ± 1.14	$3.29^{###} \pm 1.03$	5.31 ± 0.86
log LF/HF	$1.86^{**,###} \pm 0.44$	$0.50^{§§§} \pm 0.65$	1.25 ± 0.64	1.36 ± 0.64

Average and standard deviation of HRV parameters for EYT 'L exercise' and the accompanying ergometer training. VLF, LF, HF and LF/HF were log-transformed (indicated by the prefix 'log') due to their skewed distributions. §§$p < 0.01$.
** $p < 0.01$.
*** $p < 0.001$ vs. ergometer.
§§§ $p < 0.001$ vs. $rest_{Ergom}$.
# $p < 0.05$.
$p < 0.01$.
$p < 0.001$ vs. accompanying rest.

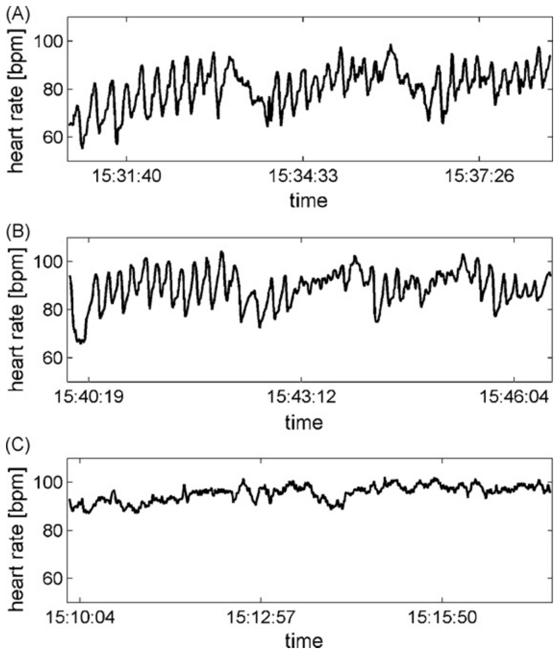

Figure 3 Examples of oscillations of the instantaneous heart rate during the EYT exercises (A) 'B exercise' and (B) 'L exercise'. Such low frequency oscillations are not visible during ergometer training (C).

($p < 0.001$; see an example in Fig. 3). During CET the heart rate was higher compared to 'B exercise' (112 bpm, $p < 0.05$) and also decreased at rest after the exercise (82 bpm, $p < 0.001$). SDNN was significantly higher during the 'B exercise' (75 ms) than during the resting period afterwards (44 ms; $p < 0.001$). The lowest SDNN (20 ms) was observed during CET and increased at rest following the exercise (51 ms, $p < 0.001$).

In the frequency domain, VLF and LF were higher during 'B exercise' compared to rest after the exercise (VLF: 7.65 vs. 6.57 log ms^2, LF: 8.06 vs. 6.15 log ms^2; $p < 0.001$). In contrast, during CET, VLF, LF and HF were lower when compared with HRV at rest after CET (VLF: 5.39 vs. 6.78 log ms^2, LF: 4.41 vs. 6.63 ms^2, HF: 3.09 vs. 5.19 log ms^2; $p < 0.001$). The LH/HF ratio was highest during 'B exercise' (1.92) and lowest at rest after 'B exercise' (0.38, $p < 0.001$). During CET, the LF/HF ratio was 1.33 and did not change during resting period after CET. At rest after CET the LF/HF ratio was also higher compared to rest after the 'B exercise' ($p < 0.001$).

HRV during and after the EYT L exercise

The 'L exercise' led to the following results: the average heart rate was 99 bpm during exercise and decreased during rest (70 bpm, $p < 0.001$). A heart rate of 108 bpm was observed during CET and decrease toward 79 bpm at rest afterward ($p < 0.001$). SDNN was highest for 'L exercise' (52 ms) and stayed constant at rest after the 'L exercise'. SDNN was lowest during CET (19 ms, $p < 0.001$ vs. 'L exercise') and increased at rest after CET (47 ms, $p < 0.001$).

In the frequency domain, only LF increased during the 'L exercise' compared to the accompanying resting period (7.19 vs. 6.25 log ms^2, $p < 0.05$). VLF (6.94 log ms^2) and HF (5.33 log ms^2) stayed constant during 'L exercise' and the subsequent resting period. During CET, VLF, LF and HF decreased comapred to 'L exercise' (VLF: 6.94 vs. 5.17 log ms^2, LF: 7.19 vs. 4.54 log ms^2, HF: 5.33 vs. 3.29 log ms^2, $p < 0.001$) and subsequently increased at rest after CET to a level similar to rest after the 'L exercise'. LF/HF was highest during the 'L exercise' (1.86) and lowest at rest after 'L exercise' (0.50, $p < 0.001$). During CET LF/HF was lower compared to 'L exercise' (1.25, $p < 0.05$) and stayed constant during the subsequent resting period.

Discussion

This is the first study on EYT that focuses on HRV. In short, during the 'B exercise' SDNN (70%), VLF (16%) and LF (31%) increased markedly whereas during 'L exercise' only LF (15%) increased markedly. Both EYT exercise showed an increase of LF/HF during the exercise and a pronounced and unexpected decrease at rest after EYT. In contrast, during CET HRV decreased. Consequently, EYT enhanced HRV whereas CET showed a reduction of HRV although both exercises had a similar workload.

A moderate increase of heart rate was observed during the EYT 'B exercise.' HRV increased as indicated by the increase of SDNN, VLF and LF. Very low frequency and low frequency oscillations are associated primarily with sympathetic activity.[18] Hence, this exercise seems to lead to strong sympathetic activation. This activation decreased during rest after the exercise. Consequently, the sympathovagal balance as expressed by log LF/HF was near 0 at rest after the exercise, indicating that both branches of the ANS were almost balanced. In contrast, CET led to a decrease of HRV in all parameters except LF/HF. This result was expected because an increase of physical activity leads to an increase of heart rate. The increase of heart rate is accompanied by an increase of sympathetic activity and a decrease of HRV.

The 'L exercise' had a different impact on HRV. In contrast to the 'B exercise', only LF increased during 'L exercise'. The increase was less pronounced compared with the increase during the 'B exercise' and, hence, the sympathetic activation was less pronounced. In comparison to 'B exercise', the decrease of LF/HF was also less pronounced. During CET HRV decreased again. The recovery of heart rate and HRV at rest after CET was similar to the recovery of the first CET. We emphasize that especially during rest after both EYT exercises the ratio LF/HF indicates an almost balanced activity of both branches of the ANS whereas after CET sympathetic activity still prevails. Hence, EYT increases HRV during the exercise and alters sympathovagal balance immediately after the exercise.

It is of note that many chronically ill patients report that various complementary psychosocial interventions, such as meditation, yoga, and Qui Gong, influence their emotional state and support them spiritually.[19] In this study, we focused on the effects of EYT on HRV. This influence is likely mediated by a variety of cardiovascular mechanisms. For instance, while squatting the venous return decreases compared to standing and, therefore, contributes to a decrease of the heart rate. In the upright position, the movement of the arms and the chest during the EYT exercise imposed different levels of pressure on the thorax, thus modulat-

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ing the venous return of blood and the respiration. These physiological mechanisms most probably contributed to the impressive effect of EYT on HRV in comparison with CET. However, other physiological mechanisms, such as the balance of the different parts of the ANS, may also be altered. Therefore, further studies are needed to elucidate these effects and their consequences for the clinical use of EYT. Particularly the long-term effects of EYT modulation of HRV in chronically ill patients have to be analyzed.

An increase in low frequency variations of heart rate was observed during slow breathing[20] and recitation of poetry.[21] If such variations are induced by respiration, they lead to an improvement of the arterial baroreflex sensitivity and a decrease in blood pressure in patients with essential hypertension.[22] In our study, special movements of the body, rather than special breathing patterns, increased low frequency oscillations of HRV. Nevertheless, this increase still seems to be positive because this increase is associated with an improvement of ones adaptability to different physical demands.[9,18] Such an improvement is desirable for patients with various indications because it strengthens at least part of the person and may lead to a better outcome. Additionally, it has been shown, that improvement of HRV parameters is linked to a better quality of life and reduced symptoms of disease in cardiac disease patients as well as in patients with other chronic diseases.[23–25]

Conclusion

In our study, we were able demonstrate that in healthy subjects the two selected EYT exercises ('B exercise' and 'L exercise') have an impressive effect on HRV during and straight after the exercise when compared to CET. Considering the correlation of enhanced HRV with increased quality of life and reduction of symptoms in chronically ill patients, EYT should be further studied in clinical trials.

Conflict of interest

None.

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