The Influence of an Eight-Week Whirling-Kung Training Course on the Heart Rate Variability

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Abstract: The purpose of this study is to explore the influence of an eight-week whirling-kung training course on the heart rate variability (HRV) in order to know whether or not practicing whirling-kung continuously for 5 to 15 minutes three times a week is helpful to physical and mental health, indicated by the HRV indicators of the subjects. Results from paired-samples t tests show that in the whirling-kung group and the walking group, the HRV components such as SDNN, TP and HF did not increase significantly as hypothesized, while LF did not decrease significantly as hypothesized. Perhaps the relatively small sample sizes and the insufficient training courses have led to these consequences. However, the SDNN and TP in the control group has a statistically significant drop ($p<0.05$), compared to their rise in both the treatment group 1 and 2, though not statistically significant, which might suggest, like the walking group (treatment group 2), whirling might have avoided the dropping of the SDNN and TP.

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1. Introduction

The “whirling-kung” in this study originates from Sufi Whirling[1], which was the major spiritual practice of Mawlawiyah, a Muslim group founded by Rumi al-Balkhi, Maulana Jalauddin[2], who died in 1273 B.C. People who practice Sufi Whirling are called Whirling Dervishes [1].

Since it was introduced to Taiwan a few years ago[3], Sufi Whirling has developed from a religion-related activity into a kind of exercise to promote body-mind balance, healing and health, just as Tai-chi has developed from a type of martial art to an activity for body training, healing, and even self-cultivation. To avoid religious connotation, we use the term “whirling-kung” to differentiate it from Sufi Whirling. The root “kung” is taken from the word kung-fu, to express its efficacy of promoting body-mind fitness through whirling. This research gave up using the term “whirling chikung” because the term chi-kung (or qi-gong) has long been overly applied and become too ambiguous in meaning.

Compared to many other activities, whirling-kung is easy to practice without complicated procedures and no equipment is needed. While practicing whirling-kung, the whirler stands upright and spins counterclockwise or clockwise on their own feet continuously for a certain period of time. The minimum time required for whirling is not our current concern and is in need of further study in the future.

What really concerns us is the influence of whirling-kung on human health, since whirling-kung is considered as an exercise to promote body-mind balance, healing and health. However, from our literature review, we did not find any rigorous research to tap into this issue. There are only numerous witnesses and self-reports by those who practice Sufi-whirling or whirling-kung. Therefore, in this research, the researchers intended to explore this issue through rigorous research.

To achieve this end, after literature review, we decided to use heart rate variability (HRV) as a simple measure of health. The Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (TFESC & NASPE) [4] claimed that 20 years before, the world has seen the recognition of a significant relationship between the autonomic nervous system and cardiovascular mortality. Evidence found in experiments for relationship between a propensity for lethal arrhythmias and signs of either increased sympathetic or reduced vagal activity has caused the development of quantitative markers of autonomic activity, of all which heart rate variability (HRV) is one of the most promising ones.

There are several ways to perform the evaluation of HRV, the easiest of which are perhaps the time domain measures. In a continuous electrocardiographic (ECG) records, the researcher can detect each QRS complex (as shown in Figure 1), and determine the normal-to-normal (NN) intervals (i.e. all intervals between adjacent QRS complexes), or the instantaneous heart rate. Among others, the simplest variable to calculate is the standard deviation of the NN interval (SDNN).

However, the durations of the recordings used to determine SDNN values, as well as other HRV measures, should be standardized and short-term 5-minute recordings and nominal 24 hour long-term recordings appear to be appropriate options.

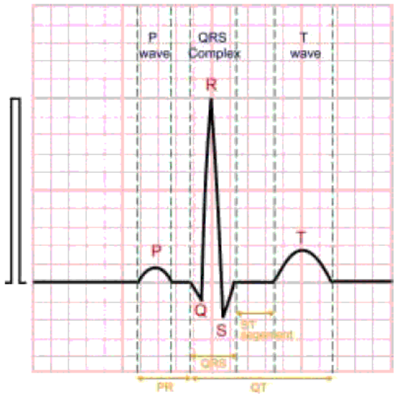

Figure 1 QRS complex: from the start of Q wave to the end of S wave (from: DailyCare BioMedical Inc.)

TFESC & NASPE [1] has summarized the variety of time–domain measures of HRV in Table 1 and has also listed selected frequency–domain measures in Table 2.

2.The HRV indexes used in this research

World Health Organization [5] defines healthy as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." According to Merriam-Webster [6] it is "the condition of being sound in body, mind, or spirit; especially: freedom from physical disease or pain." It has been found that, in poor health conditions such as aging, septicemia, chronic obstructive pulmonary disease, chronic renal failure, diabetes, hypertension, coronary heart disease, myocardial infarction or heart failure, HRV decreases. A lot of researchers have also suggested that HRV serves as an index of the autonomic activity, especially that of parasympathetic nervous systems. Autonomic, or involuntary, system regulates the visceral activity of the body, and it is composed of sympathetic and parasympathetic nervous systems [7]. The sympathetic nervous system is always on the alert for emergencies, while parasympathetic nervous system mainly reserves the energy of the body. Some researchers also came to similar conclusion [8]: Using all measures, HRV of healthy subjects declines with aging, with measure-dependent patterns. Using the SDNN index, rMSSD and pNN50, HRV of healthy subjects, particularly those >65 years old, may decrease to below levels associated with increased risk of mortality. In other words, the extent of decrease of parasympathetic activity correlates with aging or the seriousness of bad health.

In order to assess whether whirling-kung training would improve human health, we found that there are many researches that use HRV as measures to assess the influence of certain type of practices on HRV. In a typical example of this research genre [9], the researchers investigate changes in autonomic nervous function through Qi-training. The power spectrum of heart rate variability (HRV) was examined in 20 sedentary healthy subjects and 20 Qi-trainees. It was found that Qi-training in healthy young subjects during controlled respiration increases the high frequency (HF) power and decreases the low frequency / high frequency (LF/HF) power ratio of HRV. These results support the hypothesis that Qi-training increases cardiac parasympathetic tone. In addition, Qi-trainees were found to have higher parasympathetic heart modulation compared with their age-matched, sedentary counterparts. This augmented HRV in Qi-trainees provides further support for long-term Qi-training as a possible non-pharmacological cardio-protective maneuver. In conclusion, Qi-training may stabilize the autonomic nervous system by modulating the parasympathetic nervous system. In another research [10], the researcher has found that Tai-chi has a short-term effect of raising HF and dropping LF and suggested older people do Tai-chi to become healthy.

Given the similarity between whirling-kung training and the above research genre, the researchers have inferred that whirling-kung may be able to increase HRV (SDNN and TP) and parasympathetic activity (HF), and at the same time decrease sympathetic activity (LF), all of which seem to contribute to better physical and mental health. That's also why the above four indexes of HRV (SDNN, TP, LF and HF), are adopted in this research. RMSSD and pNN50 correlate between themselves and with HF power ($r = 0.96$) [11].

Table 3 summarizes why this research used SDNN, TP, LF, and HF as the Autonomic nervous activity indexes.

The purpose of this research is to develop an eight-week whirling-kung training course and to test its influence on the heath of the mind and the body by evaluating some of the HRV measures (SDNN, TP, LF and HF). If the efficacy is significant, the researchers will continue to design different courses for different ages so as to provide the busy modern people with one more pastime which is good for the body and the mind, and at the same, is easy to take up.

3.The research framework and hypotheses

This research includes three groups of subjects, in which the treatment group 1 undergoes an eight-week whirling-kung training course, the treatment group 2 undergoes the same length of time of walking, and the control group just live a normal life. Whirling-kung was assigned as the independent variables.

Table 1 Selected time-domain measures of HRV

Variable	Units	Description
SDNN	ms	Standard deviation of all NN intervals
SDANN	ms	Standard deviation of the averages of NN intervals in all 5-minute segments of the entire recording
RMSSD	ms	Square root of the mean of the sum of the squares of differences between adjacent NN interval
SDNN index	ms	Mean of the standard deviations of all NN intervals for all 5 min segments of the entire recording.
SDSD	ms	Standard deviation of differences between adjacent NN intervals
NN50 count		Number of pairs of adjacent NN intervals differing by more than 50 ms in the entire recording. Three variants are possible counting all such NN intervals pairs or only pairs in which the first or the second interval is longer.
pNN50	%	Percent of difference between adjacent NN intervals that are greater than 50 ms

Given the variety of HRV indicators, the researchers have chosen four of them that are most likely connected to practicing whirling-kung: SDNN, LF, HF, and TP.

As shown in Figure 2, there are three hypotheses in this research, as follows:

Table 2 Selected frequency domain measures of HRV

Variable	Units	Description Analysis of short-term recordings (5 min)	Frequency range
5 min total power	ms^2	The variance of NN intervals over the temporal segment	approximately≤0·4 Hz
VLF	ms^2	Power in very low frequency range	≤0·04 Hz
LF	ms^2	Power in low frequency range	0.04-0.15Hz
LF norm	n. u.	LF power in normalized units LF/(Total Power–VLF) ×100	
HF	ms^2	Power in high frequency range	0.15-0.4Hz
HF norm	n. u.	HF power in normalized units HF/(Total Power–VLF) ×100	
LF/HF		Ratio LF [ms^2]/HF [ms^2]	

Table 3 The autonomic nervous activity indexes adopted in this research

Autonomic Nervous Activity Indexes	Description
(1) SDNN	A global index of HRV and reflects all the long-term components and circadian rhythms responsible for variability in the recording period
(2) TP	The total variance and corresponds to the sum of the four spectral bands, LF, HF, ULF and VLF
(3) LF	An increase of LF has been generally considered to be a consequence of sympathetic activity
(4) HF	Generally defined as a marker of vagal modulation. This component is respiration-mediated and thus determined by the frequency of breathing

(1) After a consecutive eight-week whirling-kung training, the SDNN, HF, and TP in the treatment group 1 will rise significantly.
(2) After a consecutive eight-week whirling-kung session, the LF in the treatment group 1 will drop significantly.
(3) After a consecutive eight-week whirling-kung session, there are statistically significant differences among the post-test scores of the SDNN, HF, LF, and TP of the treatment group 1, the treatment group 2 and the control group.

4. Research methods

4.1 The Subjects

The subjects in this study are 36 senior high school freshmen or juniors from Hualien, Taiwan. To exclude the variable of gender, all of the subjects are female. In this research, there are 24 voluntary subjects randomly assigned as the treatment group 1 (practicing whirling-kung) and the treatment group 2 (walking), each with 12 subjects. In addition, the researchers have also recruited another 12 voluntary subjects and assigned them as the control group (with no experimental intervention). The subjects who are in the eight-week whirling-kung group have to open their eyes while whirling, rotate counterclockwise on their own axis, instead of revolving around a center, in order to avoid being similar to the control group.

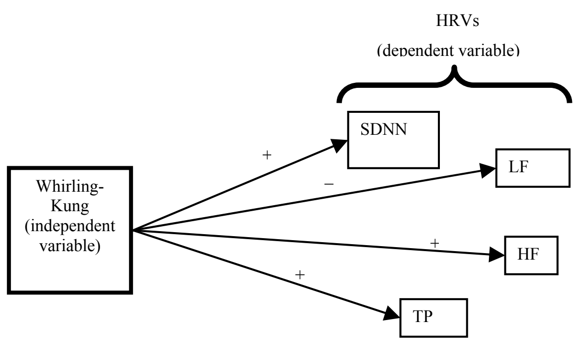

Figure 2 The Research Framework

4.2 Data Collection Method

The researchers used CheckMyHeart by Daily Care BioMedical, Inc. to measure and analyze HRV.

4.3 The Design of experiments

Twenty four voluntary subjects were randomly assigned as the whirling group (the treatment group 1, shown as X in Figure 3) and the walking group (the treatment group 2, shown as Z in Figure 3). Voluntary subjects were manually assigned as the normal living group (the control group, shown as C in Figure 3). Besides, in the treatment group 1, the duration of whirling was increased gradually from 5 minutes per session, 10 minutes per session, up to 15 minutes per session in three different stages respectively, in order to help some of the subjects gradually overcome their fear for whirling. In the treatment group 2, the duration of walking was also increased correspondingly.

The duration of the training course (i.e. the treatment) was 8 weeks, with three sessions per week. As a result, there were 24 sessions, which was divided into three stages (with 8 sessions per stage), as shown in Figure 3.

4.3.1 The Treatment Group 1 (The Whirling-kung Group)

The subjects may take turn spinning in the following three fashions. This research has no intent to probe the difference among different ways of whirling:

1. Use the left foot as the axis and move the right foot forward.
2. Use the right foot as the axis and move the left foot backward.
3. Use the body as the axis and move the left foot backward and the right foot forward simultaneously.
4. Control the whirling velocity according to the background music for whirling.
5. Move or position the arms at will.

Before the whirling session ends, the subjects may slow down gradually in accordance with the music rhythm until a full stop, or keep whirling and stop suddenly and completely when the music ends.

X	M	X1	M	X2
	M	X3	M	
Z	M	Z1	M	Z2
	M	Z3	M	
C	M		M	
	M		M	

X1: Whirling 5 minutes per session
X2: Whirling 10 minutes per session
X3: Whirling 15 minutes per session
Z1: Walking 5 minutes per session
Z2: Walking 10 minutes per session
Z3: Walking 15 minutes per session
M: Measurement of HRV

Figure 3: The design of experiments

4.3.2 The Treatment Group 2 (The Walking Group)

The subjects in the treatment group 2 perform an eight-week consecutive walking sessions in the same place as the treatment group 1 in the following manner:

1. While walking, the subjects have to walk in a large circle counterclockwise around the center of the place, in a normal "walking" fashion.
2. While walking, both feet are not allowed to lose contact with the floor at the same time.
3. While walking, the subjects are not allowed to rotate on their own axis in order to avoid being similar to the treatment group 1.
4. While walking, the subjects are required to walk in accordance with the tempo of the accompanying music to control the speed.
5. Before the walking session ends, the subjects may slow down gradually in accordance with the music rhythm until a full stop, or keep walking and stand still

suddenly and completely when the music ends.

4.3.3 The Control Group (The Normally Living Group)

The subjects only have to lead a normal life, with neither whirling nor walking consecutively. However, during the eight-week research session, they are required to avoid spinning continuously like doing whirling-kung for more than five minutes.

4.3.4 Controlling Interference Variables

1. All the subjects are not allowed to run or jog for a certain amount of time and distance during the eight-week research.
2. During the eight-week research, no subjects are allowed to take part in any other new physical activity or similar program.
3. The treatment group 1 and the treatment group 2 have to carry out the research plan simultaneously in the same place for the same length of time.
4. Each time when the experiment starts, the treatment group 1 and the treatment group 2 have to move to the music. When the experiment ends, all the subjects are allowed to stay where they are and take a rest.

4.3.5 The Duration of the Experiment

The experiment was conducted from approximately 12:45 to 13:15 on Mondays, Wednesdays, and Fridays within an eight-week period between March and May in 2011. The first to the eighth sessions lasted 5 minutes, and the ninth to the sixteenth sessions lasted 10 minutes, and the seventeenth to the twenty-fourth sessions lasted 15 minutes.

5. DATA PROCESSING AND STATISTICAL ANALYSIS

The data acquired from the study have been processed by SPSS17.0 to test and analyze the following:

1. Paired-samples t tests for the three groups, to see whether there are statistically significant differences between their pre-tests and post-tests.

2. ANCOVA, using pre-tests as covariances to find out whether there are statistically significant differences among the three groups.

3. Set $\alpha=0.05$.

5.1 Paired-samples t tests for the treatment group 1 (whirling)

The paired-samples t tests for treatment group 1 are as follows:

For SDNN of the treatment group 1, $t(11) =-0.597$, $p>.05$, so there is no statistically significant difference between the pre-test and the post-test. For LF, $t(11) =0.201$, $p>.05$, so there is no statistically significant difference between the pre-test and the post-test. For HF, $t(11) =-1.240$, $p>.05$, so there is no statistically significant difference between the pre-test and the post-test. For T, $t(11) =-0.703$, $p>.05$, so there is no statistically significant difference between the pre-test and the post-test.

5.2Paired-samples t tests for the treatment group 2 (walking)

During the experiment, one of the subjects in the group dropped out, so the sample size became 11. The paired-samples t tests for the treatment group 2 are as following:

For SDNN of the treatment group 2, $t(10) =-0.605$, $p>.05$, so there is no statistically significant difference between the pre-test and the post-test. For LF, $t(10) =-1.338$, $p>.05$, so there is no statistically significant difference between the pre-test and the post-test. For HF, $t(10) =0.409$, $p>.05$, so there is no statistically significant difference between the pre-test and the post-test. For T, $t(10) =-0.691$, $p>.05$, so there is no statistically significant difference between the pre-test and the post-test.

5.3Paired-samples t tests for the control group (normal)

During the research, one of the subjects in the group dropped out, and HRV data of two of them had been unable to be measured, so the sample size became 9. The paired-samples t tests for the control group are as following:

For SDNN of the control group, $t(9) =2.640$, $p=.030<.05$, so there is a statistically significant difference between the pre-test and the post-test. For LF, $t(9) =1.855$, $p=.101>.05$, so there is no statistically significant difference between the pre-test and the post-test. For HF, $t(9) =1.997$, $p=.081>.05$, so there is no statistically significant difference between the pre-test and the post-test. For T, $t(9) =.042<.05$, so there is a statistically significant difference between the pre-test and the post-test.

5.4 ANCOVA

Analysis of covariances (ANCOVA) is applied to test whether there are any statistically significant differences among the post-tests of HRV from the three groups. First, using “group” as dependent variable, the pre-tests as fixed factors, and the post-tests as covariates, the researchers used Univariate Analysis of Variance and got the following tables:
Before doing ANCOVA, the test of homogeneity of variance is needed.

Table 4 Comparison of pre-test and post-test from the treatment group 1

	Source	N	M	SD	df	t
SDNN	Pre-test	12	51.15	22.54	11	-0.597
	Post-test	12	55.27	443.55		
LF	Pre-test	12	447.83	509.72	11	0.201
	Post-test	12	423.50	443.55		
HF	Pre-test	12	456.42	374.76	11	-1.240
	Post-test	12	716.58	860.90		
TP	Pre-test	12	1511.42	1321.81	11	-0.703
	Post-test	12	1853.75	2071.80		

α=0.05

Table 5 Comparison of pre-test and post-test from the treatment group 2

	Source	N	M	SD	df	t
SDNN	Pre-test	11	51.99	15.34	10	-0.605
	Post-test	11	55.62	22.10		
LF	Pre-test	11	432.91	384.31	10	-1.338
	Post-test	11	656.27	713.56		
HF	Pre-test	11	417.91	232.30	10	0.409
	Post-test	11	383.09	277.33		
TP	Pre-test	11	1362.45	847.00	10	-0.691
	Post-test	11	1624.18	1297.13		

α=0.05

Table 6 Comparison of pre-test and post-test from the control group

	Source	N	M	SD	df	t
SDNN	Pre-test	9	64.97	14.40	8	2.640*
	Post-test	9	47.72	10.74		
LF	Pre-test	9	576.78	307.09	8	1.855
	Post-test	9	330.56	255.54		
HF	Pre-test	9	691.67	377.27	8	1.997
	Post-test	9	414.78	345.62		
TP	Pre-test	9	2043.11	927.24	8	2.420*
	Post-test	9	1105.22	525.54		

α=0.05

Table 7 Test of homogeneity of variance within groups:

Source	F	Description
Group * SDNN Pre-test	1.076	F=1.076, p>.05, not statistically significant
Group * LF Pre-test	2.064	F=2.064, p>.05, not statistically significant
Group * HF Pre-test	1.182	F=1.182, p>.05, not statistically significant
Group * TP Pre-test	1.497	F=1.497, p>.05, not statistically significant

p <.05

From the Table 7, the homogeneity of variance within groups is not violated, so ANCOVA can be done.

Table 8 Analysis of Covariance

	Source	SS	df	MS	F
SDNN	Group	385.736	2	192.868	.503
	Error	10735.785	28	383.421	
	Total	11121.521	30		
LF	Group	580882.096	2	290441.048	1.443
	Error	5637091.507	28	201324.697	
	Total	6217973.603	30		
HF	Group	769294.494	2	384647.247	1.372
	Error	7851727.635	28	280418.844	
	Total	8621022.129	30		
TP	Group	2941591.433	2	1470795.717	.774
	Error	53239131.070	28	1901397.538	
	Total	56180722.500	30		

$p < .05$

For SDNN, F(2, 30)=.503, for LF, F(2,30)=1.443, for HF, F(2,30)= .372, and for TP, F(2,30)= .774, there are therefore no differences among HRV post-tests of the three groups. The following is a summary of ANCOVA.

Table 9 The means, standard deviation, and adjusted mean of the pre-tests, post-tests of the three groups:

Dependent variables	Groups	Pre-test			Post-test		
		N	Mean	SD	Mean	SD	Adjusted Mean
SDNN	Treatment 1	12	51.15	22.54	55.27	25.54	57.29
	Treatment 2	11	51.99	15.34	55.62	22.10	57.24
	Control	9	64.97	14.40	47.72	10.74	43.06
LF	Treatment 1	12	447.83	509.72	423.50	443.55	443.70
	Treatment 2	11	432.91	384.31	656.27	713.56	686.15
	Control	9	576.78	307.09	330.56	255.54	267.12
HF	Treatment 1	12	456.42	374.76	716.58	860.90	758.56
	Treatment 2	11	417.91	232.30	383.09	277.33	455.60
	Control	9	691.67	377.27	414.78	345.62	270.21
TP	Treatment 1	12	1511.42	1321.81	1853.75	2071.80	1915.25
	Treatment 2	11	1362.45	847.00	1624.18	1297.13	1778.83
	Control	9	2043.11	927.24	1105.22	525.54	834.21

6. Conclusions

According to the statistical results, after an eight-week whirling-kung program, neither of the HRV data from the treatment group 1 and 2 has shown significant differences. Perhaps the relatively small sample sizes have led to these consequences, for it's quite hard to make potential voluntary subjects conquer the fear for whirling. The statistical results show that, in either the treatment group 1 or 2, the SDNN, TP, and HF haven't risen significantly, and the LF in them hasn't dropped significantly, either. However, the SDNN and TP in the control group has a statistically significant drop, ($p<0.05$), compared to their rise in both the treatment group 1 and 2, though not statistically significant, which might suggest, like the walking group (treatment group 2), whirling might have avoid the dropping of SDNN and TP.

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