THE IMPACT OF CONTINOUS VERSUS INTERVAL TRAINING ON HEART RATE VARIABILITY AND PULMONARY CAPACITY AMONG ELDERLY

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ABSTRACT

Background: Regular exercise training program had benefited from the possible improvements in the cardiopulmonary system which induced heart rate variability and vital capacity. Objectives: To detect the effect of continous versus interval training program on heart rate variability and pulmonary capacity among elderly. Design: A prospective, randomized, single-blind design. Setting: ElQuanater Central Hospital outpatient clinic for picking up leads of twenty four hour ECG holter monitoring and using spirometer for detecting the vital capacity. Participants: Forty healthy nonathletic participants of both sexes were randomly allocated to 2 equal groups (in number). Interventions: Each group (n=20) passed through heart rate variability and pulmonary capacity measurements before the exercise training program, then after the end of the total study period (12 weeks), subjects of group (A) performed a supervised continous aerobic exercise program of moderate intensity, with a score of 12-14 on the Borg scale for perceived exertion performed on an electronic treadmill. The exercise program consisted of 40 minutes on an electronic treadmill, with a warm-up and a cool-down period of 5 minutes each and 30 minutes as an active phase, 3 times per week for 3 months. Subjects in group (B) performed a supervised moderate intensity interval aerobic exercise program performed on an electronic treadmill. Subjects alternated between moderate intensity exercise work intervals, i.e. score 12 - 14 on Borg scale for RPE and a recovery interval i.e. score 9 - 10 on Borg scale for RPE. The work and recovery intervals were adjusted so the work intervals were longer (as much as 10 minutes) and the recovery intervals were shorter (such as two minutes). The recovery intervals were twice per session. Subjects received 3 sessions per week, 40 minutes per session for 12 weeks.

Results: There were no significant difference in the HRV between group A and B post exercise (p = 0.33) and MD 21.25 ms, there were no significant difference in the VC between group A and B post exercise (p = 0.45) and MD 0.13L. Conclusion: continous versus interval regular aerobic exercise training program had a positive effect on increasing heart rate variability and pulmonary capacity among elderly.

Keywords: Continous aerobic exercise, Interval training, Heart rate variability, pulmonary capacity, elderly.

Abbreviations

ECG: Electrocardiography.
HRV: Heart rate variability.
ANS: Autonomic nervous system.
VC: Vital Capacity.
FVC: Forced vital capacity.

RPE: Rate of perceived exertion.

MD: Mean difference.

SPSS: Statistical package for social studies

I. INTRODUCTION

Heart rate variability (HRV) is the physiological phenomenon of variation in the time interval between heartbeats. It is measured by the variation in the beat-to-beat interval\(^1\).

Heart rate variability (HRV) is a widely used physiological variable that non-invasively assesses the cardiac autonomic nervous system (ANS) by measuring the changes in the cardiac rhythm through time. HRV is considered as a reflection of changes of the cardiac sympathetic and parasympathetic branches of the ANS. Several models have been proposed to explain HRV, which could describe the relationship between HRV, vagal tone and several physiopathological processes\(^2\).

Vital capacity (VC) is the maximum amount of air a person can expel from the lungs after a maximum inhalation. It is equal to the sum of inspiratory reserve volume, tidal volume, and expiratory reserve volume. It is approximately equal to Forced Vital Capacity (FVC)\(^3\).

A person's vital capacity can be measured by a wet or regular spirometer. In combination with other physiological measurements, the vital capacity can help make a diagnosis of underlying lung disease. Furthermore, the vital capacity is used to determine the severity of respiratory muscle involvement in neuromuscular disease, and can guide treatment decisions in Guillain–Barré syndrome and myasthenic crisis\(^4\).

Interval training is a type of training that involves a series of high intensity workouts interspersed with rest or relief periods. The high-intensity periods are typically at or close to anaerobic exercise, while the recovery periods involve activity of lower intensity. Varying the intensity of effort exercises the heart muscle, providing a cardiovascular workout, improving aerobic capacity and permitting the person to exercise for longer and/or at more intense levels\(^5\).

Interval training can refer to the organization of any cardiovascular workout (e.g., cycling, running, rowing). It is prominent in training routines for many sports, but is particularly employed by runners\(^6\).

Continuous Training, also known as continuous exercise or steady state training, is any type of physical training that involves activity without rest intervals. Continuous training can be performed at low, moderate, or high exercise intensities, and is often contrasted with interval training, often called high-intensity interval training. Some training regimens, such as Fartlek, combine both continuous and interval approaches\(^7\).

Exercise modes noted as suitable for continuous training include indoor and outdoor cycling, jogging, running, walking, rowing, stair climbing, simulated climbing, Nordic skiing, elliptical training, aerobic riding, aerobic dancing, bench step aerobics, hiking, in-line skating, rope skipping, swimming, and water aerobics\(^8\).

Ageing or aging is the process of becoming older. The term refers especially to humans, many others animals and fungi, whereas for example bacteria, perennial plants and some simple animals are potentially biologically immortal. In the broader sense, ageing can refer to single cells within an organism which have ceased dividing (cellular senescence) or to the population of a species (population ageing)\(^9\).

Finally, we can say that a regular interval versus continuous aerobic exercise training program may serve as a promising therapeutic modality resulting in a significant improvement of heart rate variability and pulmonary capacity levels which are predictors of future disability in older adults. So, reduce the risk of cardiovascular and pulmonary diseases in elderly.
II. INSTRUMENTATIONS AND METHODS

Study design:

This study was a prospective, pre-test, post-test, randomized, single-blind study. Prior to initiating the study, ethical approval was attained from the institutional review board at (P.T.REC/012/00296). The study followed the guidelines set by the Hospital Declaration of human subjects and was carried out between September 2019 to March 2020.

Participants and sample size:

A forty convenience nonprobability sample was recruited through a flyer distributed at the outpatient internal medicine clinic of El-Kanater Central Hospital. Informed consent was attained from each participant after clarifying the scope and objectives of the research and, ensuring them of their right to decline at any time and of the privacy of any information obtained. All data were coded to ensure privacy.

Participants were eligible to be included if their age ranges from 60–70 years, body mass index is ranged from 25 to 29.9 kg/m² and they are healthy non-athletic. Participants were excluded if; they had orthopedic problems (history of knee or back disorders), cardiovascular instability, chronic chest diseases, or deficits in perception or cognition.

To explore the accuracy and estimate the size of the needed sample, a pilot study was carried out on 40 participants (20 in each group) considering the continous versus interval regular aerobic exercise training program had a positive effect on increasing heart rate variability (HRV) among elderly as primary outcomes. Then, the continous versus interval regular aerobic exercise training program had a positive effect on increasing vital capacity (VC) among elderly as secondary outcomes, was used [Paired t test: Special effect and interaction, p < 0.05, effect size=0.25] and indicated that the proper sample size for this study was N=40]. 40 participants were recruited.

Blinding and randomization:

Random allocation of participants into 2 equal (in number) groups was done by an independent researcher who opened enclosed envelopes containing computer-generated randomization serially numbered index cards. Identification numbers were withdrawn for each participant. One number was used to assign participants in first group, and the other number was used to assign them in second group. There were no dropouts among the participants throughout the study after randomization.

Interventions:

After randomization, all interventions were done in the outpatient internal medicine clinic of El-Kanater Hospital. The groups (n=40) passed through measuring heart rate variability (HRV) and vital capacity (VC) randomly before the treatment. All procedures were carefully standardized in 2 separate sessions, so that each participant received one procedure (continous or interval) at each session, that were for 12 weeks, such that 20 subjects of first group (11 men and 9 women) were participated in a supervised moderate-intensity (score 12-14 on Borg scale for rate of perceived exertion) continous aerobic exercise program performed on an electronic treadmill for 40 minutes (5 minutes for warming-up, 30 minutes for work phase, 5 minutes for cooling-down), 3 times per week. Twenty subjects of second group (10 men and 10 women) participated in a supervised moderate-intensity interval training program [moderate intensity exercise work intervals, i.e. score 12 - 14 on Borg scale for RPE and a recovery interval i.e. score 9 - 10 on Borg scale for RPE, the work and recovery intervals were adjusted so the work intervals were longer (as much as 10 minutes) and the recovery intervals were shorter (such as two minutes)] performed on an electronic treadmill for 40 minutes, 3 times per week, for 12 weeks.

Twenty – four hour ECG holter monitoring was done to subjects in both groups pre and post study (12 weeks). Recording of the electrical activity of the heart.

pirometer was done to subjects in both groups pre and post study (12 weeks). Recording of the vital capacity.

Outcome measures:

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The primary outcomes were that continuous versus interval regular aerobic exercise training program had a positive effect on increasing heart rate variability (HRV) among elderly, while the secondary outcomes were that continuous versus interval regular aerobic exercise training program had a positive effect on increasing vital capacity (VC) among elderly. The assessment was performed pre and post exercise using twenty four hour ECG holter monitoring and spirometer.

Data analysis
Descriptive statistics and t-test were conducted for comparison of the mean age, weight, height and BMI between both groups.

Chi squared test were conducted for comparison of sex distribution between both groups.

Unpaired t-test was conducted for comparison of HRV and VC between groups.

Paired t test for comparison between pre and post treatment mean values HRV and VC in each group.

The level of significance for all statistical tests was set at p < 0.05.

All statistical measures were performed through the statistical package for social studies (SPSS) version 25 for windows.

III. RESULTS

General characteristics of the subjects:

Group A:
Twenty elderly subjects were included in this group. Their mean ± SD age, weight, height and BMI were 65.75 ± 3.02 years, 75 ± 6.67 kg, 167.05 ± 5.61 cm and 26.84 ± 1.45 kg/m² respectively as shown in table (1) and figure (1-4).

Group B:
Twenty elderly subjects were included in this group. Their mean ± SD age, weight, height and BMI were 64.85 ± 3.66 years, 75.75 ± 7.71 kg, 169.2 ± 6.97 cm and 26.39 ± 1.03 kg/m² respectively as shown in table (1) and figure (1-4).

Comparing the general characteristics of the subjects of both groups revealed that there was no significance difference between both groups in the mean age, weight, height, or BMI (p > 0.05).

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>MD</th>
<th>t- value</th>
<th>p-value</th>
<th>Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>65.75 ± 3.02</td>
<td>64.85 ± 3.66</td>
<td>0.9</td>
<td>0.84</td>
<td>0.4</td>
<td>NS</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>75 ± 6.67</td>
<td>75.75 ± 7.71</td>
<td>-0.75</td>
<td>-0.32</td>
<td>0.74</td>
<td>NS</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>167.05 ± 5.61</td>
<td>169.2 ± 6.97</td>
<td>-2.15</td>
<td>-1.07</td>
<td>0.29</td>
<td>NS</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26.84 ± 1.45</td>
<td>26.39 ± 1.03</td>
<td>0.45</td>
<td>1.13</td>
<td>0.26</td>
<td>NS</td>
</tr>
</tbody>
</table>

- MD: Mean difference
- t-value: Unpaired t value
- p-value: Probability value
- Sign: Non significant

Table 1. Descriptive statistics and t-test for comparing the mean age, weight, height and BMI of group A and B.
Figure (1). Mean age of both groups (A and B).

Figure (2). Mean weight of both groups (A and B).

Figure (3). Mean height of both groups (A and B).
Sex distribution:

The sex distribution of the group A revealed that there were 9 females with reported percentage of 45% while the number of males was 11 with reported percentage of 55%. The sex distribution of the group B revealed that there were 10 females with reported percentage of 50% while the number of males was 10 with reported percentage of 50%. There was no significant difference in sex distribution between group A and B (p = 0.75). (Table 2, figure 5).

Table 2. The frequency distribution and chi squared test for comparison of sex distribution between both groups (A and B).

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>χ² value</th>
<th>p-value</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>9 (45%)</td>
<td>10 (50%)</td>
<td>0.1</td>
<td>0.75</td>
<td>NS</td>
</tr>
<tr>
<td>Males</td>
<td>11 (55%)</td>
<td>10 (50%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

χ²: Chi squared value  
p value: Probability value  
NS: Non significant

HRV

I. Pre treatment mean values of HRV of both groups (A and B):

The mean ± SE HRV pre treatment of group A was 622.5 ± 15.04 ms and that of group B was 613.5 ± 15.66 ms. The mean difference between both groups was 9 ms. There was no significant difference in the HRV between group A and B pre treatment (p = 0.68). (Table 3, figure 6).
Table 3. Comparison of pre treatment mean values of HRV between group A and B:

<table>
<thead>
<tr>
<th></th>
<th>HRV (ms)</th>
<th>MD</th>
<th>t-value</th>
<th>p-value</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>622.5 ± 15.04</td>
<td>9</td>
<td>0.41</td>
<td>0.68</td>
<td>NS</td>
</tr>
<tr>
<td>Group B</td>
<td>613.5 ± 15.66</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( \overline{X} \): Mean
SE: Standard error
MD: Mean difference
t value: Unpaired t value
p value: Probability value
NS: Non significant

Figure (6). Pre treatment mean values of HRV of group A and B.

II. Post treatment mean values of HRV of both groups (A and B):

The mean ± SE HRV post treatment of group A was 647 ± 15.54 and that of group B was 625.75 ± 15.28. The mean difference between both groups was 21.25 ms. There was no significant difference in the HRV between group A and B post exercise (p = 0.33). (Table 4, figure 7).

Table 4. Comparison of post treatment mean values of HRV between group A and B:

<table>
<thead>
<tr>
<th></th>
<th>HRV (%)</th>
<th>MD</th>
<th>t-value</th>
<th>p-value</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>647 ± 15.54</td>
<td>21.25</td>
<td>0.97</td>
<td>0.33</td>
<td>NS</td>
</tr>
<tr>
<td>Group B</td>
<td>625.75 ± 15.28</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( \overline{X} \): Mean
t value: Unpaired t value
SE: Standard error
MD: Mean difference	p value: Probability value
NS: Non significant

Figure (7). Post treatment mean values of HRV of group A and B.
I. Pre treatment mean values of VC of both groups (A and B):

The mean ± SD VC pre treatment of group A was $2.87 \pm 0.5$ L and that of group B was $2.81 \pm 0.58$ L. The mean difference between both groups was $0.06$ L. There was no significant difference in the VC between group A and B pre treatment ($p = 0.73$). (Table 5, figure 8).

Table 5. Comparison of pre treatment mean values of VC between group A and B:

<table>
<thead>
<tr>
<th></th>
<th>VC (L)</th>
<th>MD</th>
<th>t-value</th>
<th>p-value</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>$2.87 \pm 0.5$</td>
<td>0.06</td>
<td>0.34</td>
<td>0.73</td>
<td>NS</td>
</tr>
<tr>
<td>Group B</td>
<td>$2.81 \pm 0.58$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure (8). Pre treatment mean values of VC of group A and B.

II. Post treatment mean values of VC of both groups (A and B):

The mean ± SD VC post treatment of group A was $3.32 \pm 0.46$ L and that of group B was $3.19 \pm 0.64$ L. The mean difference between both groups was $0.13$ L. There was no significant difference in the VC between group A and B post treatment ($p = 0.45$). (Table 6, figure 9).

Table 6. Comparison of post treatment mean values of VC between group A and B:

<table>
<thead>
<tr>
<th></th>
<th>VC (L)</th>
<th>MD</th>
<th>t-value</th>
<th>p-value</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>$3.32 \pm 0.46$</td>
<td>0.13</td>
<td>0.75</td>
<td>0.45</td>
<td>NS</td>
</tr>
<tr>
<td>Group B</td>
<td>$3.19 \pm 0.64$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

VC: Mean; SD: Standard deviation; MD: Mean difference; t value: Unpaired t value; p value: Probability value; NS: Non significant
Adverse events

There were no adverse events recorded throughout the study.

IV. DISCUSSION

The purpose of this study was developed to find out the effect of continuous versus interval training program on heart rate variability and pulmonary capacity among elderly.

The findings of the present study examined the effects of exercise on heart rate variability as a study in which, heart rate variability had been studied over the last 2 years, especially its relation to a higher risk of cardiovascular mortality. Some of the changes that took place in heart rate control at rest and at exercise submaximal levels were consequence of intrinsic adaptations of the sinus node, an increase in venous return and systolic volume, and improved myocardial contractility; or peripheral, such as improved oxygen extraction (oxygen arteriovenous difference), causing heart rate to reduce to those (submaximal) required levels.

The selection of heart rate variability and pulmonary capacity in this study was to have been emerged as predictors of future disability in older adults thus, the effects of physical activity on the cardiopulmonary system, and overall it appeared that moderate intensity of physical activity on a regular basis can increase the amount of heart rate variability and pulmonary capacity that was produced in the older adults.\textsuperscript{10}

Research work done by Gavrilova, (2016) may explain the concept that physical fitness promotes cardiovascular health. This study examined the effects of fitness on heart rate variability in response to an acute exercise challenge. The findings indicate that Increased fitness level had little effect on indexes of heart rate variability, which reflect parasympathetic or mixed sympathetic/parasympathetic modulation of heart rate. The findings provide evidence of how physical fitness might protect individuals from cardiovascular problems responses to exercise.\textsuperscript{11}

The results also in agreement with the results of Fronchetti et al., (2007) who showed that the autonomic modulation during the incremental exercise was altered by interval training. In addition, the work load at heart rate variability (HRV) threshold, was significantly greater after the training period. The present study shows that 3-weeks of high-intensity interval training induces a significant increase on the work load at HRV threshold. it is suggested that 3-weeks of high-intensity interval training results in delay of parasympathetic withdrawal during progressive exercise.\textsuperscript{12}

These results are supported also by Backer et al., (2018) who mentioned that vital capacity is strong indicator of lung function which decline due to sedentary lifestyle. Many studies shows that an increase in vital capacity and lung volumes has positive effect on increasing work capacity and power output. A spirometer is an important instrument in the assessment of the lung functions.\textsuperscript{13}
This concept was supported by Butterworth et al., (2003) who studied the effect of moderate intensity aerobic exercise on pulmonary capacity in elderly. This pilot study documented the effect of a 10-week walking program on pulmonary capacity among older adults. The exercise group experienced a significant improved pulmonary capacity scores after the course of exercise, a significant increase in vital capacity level (from 4.14 ± 0.32 to 4.49 ± 0.26, p < 0.001). They conclude that aerobic exercise program improves pulmonary capacity in elderly.

Also, Blissmer et al., (2011) studied that interval training increases cardiorespiratory fitness and exercise capacity when compared with no exercise and produces a similar magnitude of change as continuous exercise in elderly people.

The Mac Arthur Studies of Successful Aging found that Exercise training increases total heart rate variability in normal older adults. The most marked alterations are in nocturnal heart rate. Heart rate variability is stable over a 1-year period in older adults who do not alter their activity level.

Clearly, the cardiopulmonary adaptations made to dynamic and static exercise show the amazing ability of the human body to alter physiological processes in order to meet metabolic demands. A remarkable partnership that allows individuals to maximize their abilities and obtain goals exists between the cardiovascular and pulmonary systems. The adaptations of the cardiopulmonary system depend heavily on the intensity, duration, frequency, and type of exercise being performed. An appropriate exercise program allows for improvements in the cardiopulmonary system that help develop and maintain fitness levels.

The present study expands the knowledge of health benefits derived from physical activity by documenting a specific intensity, frequency, and duration of physical activity sufficient to produce higher heart rate variability and pulmonary capacity levels, details that are extremely important for clinical practice.

Finally, we can say that a regular interval versus continuous aerobic exercise training program may serve as a promising therapeutic modality resulting in a significant improvement of heart rate variability and pulmonary capacity levels which are predictors of future disability in older adults. So, reduce the risk of cardiovascular and pulmonary diseases in elderly.

V. CONCLUSION:

The results of this study supported the importance of exercise training program for elderly and showed that continuous versus interval regular aerobic exercise training program had a positive effect on increasing heart rate variability and pulmonary capacity among elderly. Hence, would reduce the risk of future disability in older adults.

Acknowledgment

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Conflicts of interest

The authors declare no conflicts of interest.

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