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Abstract

Background: Older people are placed in different body positions for medical, nursing and physiotherapy intervention.

Objective: To investigate the effect of body position on cardio-respiratory variables in active older people.

Design: Experimental laboratory study.

Setting: Research was undertaken at the James Cook University, Physiotherapy Clinic.

Subjects: Twenty-six active people aged 60 years and over.

Methods: Heart rate, systolic and diastolic blood pressure and oxygen saturation were measured every two minutes over a ten minute period in five standardized positions, sitting, right side lying, left side lying, supine and supine with the head 20 degrees below the level of the body. Rate pressure product and mean arterial pressure were calculated. Smoking history, medication use, health conditions and activity level were recorded. Height, weight and body fat were measured.

Results: Left and right side lying produced significantly lower diastolic and systolic blood pressure, rate pressure product and mean arterial pressure than supine with the head down. Further diastolic blood pressure and mean arterial pressure were significantly higher in sitting than right or left side lying. No significant difference in heart rate or oxygen saturation occurred with the adoption of each body position. Excluding oxygen saturation mean values for all other variables remained within recommended normal limits in all positions.

Conclusions: Significant differences in cardio-respiratory variables occur when active older people change body position. Positioning as a treatment intervention appears safe in supine,
side lying and sitting for this population. Head down supine position should be adopted with caution.

**Introduction**

Body position alters the effect of gravity on body function hence positional advice is often implemented in the management of cardiovascular, respiratory, digestive and musculoskeletal conditions [1]. Positions commonly adopted for medical, nursing and physiotherapy management, rest and sleep include sitting, lying supine or lying in the lateral position. Further, lying supine with the head positioned inferior to the body is used by physiotherapists to treat respiratory conditions. There is little evidence to determine the potentially detrimental effects of positioning alone as a treatment [2]. This is important in older people who may have age-related compromise of cardio-respiratory function.

Reported findings related to body position and cardio-respiratory factors have varied for healthy, young adults [3-5] and one study has investigated these factors in a middle aged group [6]. Numerous studies have reported the effect of body position on cardio-respiratory function in specific patient groups [7-15]. However there is scant information regarding the effect of body position on cardio-respiratory variables in older people. Due to age related cardio-respiratory changes it is unlikely that findings in young and middle aged adults are generalisable to an older population. Factors which may alter cardio-respiratory response to different body positions include obesity, history of smoking, medication use, presence of medical conditions and general fitness level.

Older, healthy people have decreased forced vital capacity and forced expiratory volume after one second in side lying when compared to sitting [16]. Further healthy, seated older subjects
 (>65 years) have significant impairment of ventilation distribution to dependent lung zones [17].

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Older people exhibit significant increased preference for the right side sleep position [18]. This has been postulated to be due to age related alterations in cardiovascular function [18] or compression from other structures causing reduction in ventricular distensibility [19].

This study investigates the effect of five standardised body positions on cardio-respiratory variables in a group of healthy, older people. Comparisons are made to previously reported findings for young and middle aged healthy people.

**Methodology**

The method of this observational study largely replicates Jones & Dean [4]. It is described here for the convenience of the reader and to identify alterations for this study.

Participants were recruited from four Probus clubs (a community organisation for people aged over 60 years) in Townsville, Australia. Human research ethics approval was provided by James Cook University and signed informed consent was gained prior to participation.

Participants were eligible to participate if they were over 60 years of age. A screening questionnaire (see Appendix 1 in the supplementary data on the journal website) was completed by participants to identify the presence of any physical or medical condition which would prevent participants from comfortably adopting each position included in the study for 20 minutes. Information regarding smoking history, usual exercise level, medication use, medical history and recent illness was also collected.
Anthropometric measures

Height was measured using a portable stadiometer and mass was measured using digital scales (BF-681, Tanita UK, Middlesex) as per the protocols described by Norton & Olds [20]. A measure of body fat using bioelectrical impedance analysis was provided by the digital scales. For these measures participants were required to remove their shoes and socks but not their clothes.

Standardised body positions

Physiological measures were taken in five standardised body positions;

Sitting (S), the participant sat in a standard office chair with the ankles and hips at right angles and feet on the floor. The arms were relaxed, and the hands were rested in the lap.

Horizontal supine flat position (HS), the participant lay horizontally on an examination table with their head supported by a pillow.

Head-down (20°) supine flat position (HDS), the participant was positioned in the horizontal supine position with a pillow supporting their head. The examination table was angled downwards at 20° so that from the waist to the head participants were angled downwards.

Right- and left-side lying (90°) positions (RSL and LSL, respectively) the participant lay with the trunk at 90° to the examination table. To avoid the participant shifting position, pillows were positioned to support the head to maintain vertebral alignment, and under the upper leg, which was positioned with hip flexion standardised at 45°.
In all recumbent positions, the arms rested comfortably in front of the participant. The order of position was randomised by ballot for each participant.

**Physiological measures**

Heart rate (HR) and arterial saturation of haemoglobin (SpO₂) were measured using a pulse oximeter [21] attached to the index finger. Blood pressure (BP) was measured with a manual system aneroid sphygmomanometer and spirit majestic stethoscope [22]. The BP cuff was applied to the mid-humerus of the right arm at the level of the heart and when in the right side lying position to the mid-humerus of the left arm.

**Procedure**

Before testing, participants did not to undertake any unusual activity for 24 hours and on the day of testing refrained from caffeinated beverages, unusual exercise, heavy meals, and undue stress prior to the data collection session [4]. All measurements were undertaken in the Physiotherapy Clinic at James Cook University. The temperature (23° Celsius) and humidity of the clinic was constant across testing sessions.

On arrival at the clinic participants’ anthropometric measures were taken. Participants then sat quietly for 30 minutes before being placed in their first test position. After the participants had been resting in this position for 10 minutes, all physiological measures were taken every two minutes over a further 10 minute period. Participants therefore rested in each position for 20 minutes. Additionally when participants were in HDS data was recorded every two minutes for the first 10 minutes as well as the second 10 minutes. After data collection in the first position, based on the random order, the participant was slowly positioned in the subsequent randomised
position. Participants were asked to avoid excessive movement when changing from one position to another and to avoid talking while resting in each position. The total time for data collection was approximately two hours and 15 minutes, including 30 minutes of baseline rest and 10 minutes rest and 10 minutes measurement time in each of the five body positions.

**Data Management**

For purposes of analysis, rate pressure product (RPP) was defined as the product of HR and SBP [23]. Mean arterial pressure (MAP) was calculated using the equation MAP = DBP + ⅓(SBP-DBP) [24].

Participant’s level of physical activity was classified as [25]:

- sedentary: seated work with discretion and requirements to move around but little or no strenuous leisure activity
- slightly active: standing work eg housewife
- moderately active: significant amounts of sport or strenuous activity 30-60 minutes, 4-5 times a week, and
- very active: Strenuous work or highly active therefore >30-60minutes, five times /week

Smoking history was classified into: never smoked, ceased more than 20 years ago or ceased less than or equal to 20 years ago. The cut off point of 20 years was chosen due to studies reporting the reduced risk of coronary heart disease and lung cancer gradually returns towards normal over a 20 year period [26].
Participants were asked to disclose their current medications. For statistical analysis the medications were grouped according to medication types:

- Anti hypertensive
- Anti-cholesterol
- Anticoagulant
- Diabetic medication
- Medication to treat/ prevent osteoporosis
- Gastrointestinal/ anti reflux
- Medication to treat/ prevent gout
- Hormone replacement medication
- Non steroidal anti-inflammatory medications
- Respiratory medications

**Data Analysis**

Numerical data was approximately normally distributed and was therefore described using mean value and standard deviation (SD). To test the influence of five positions (RSL, LSL, S, HS, HDS) on resting HR, SBP DBP, SpO₂, RRP and MAP repeated measures analyses of variance (ANOVA) were conducted. If the overall ANOVA result was significant, paired t-tests adjusted for multiple testing using Bonferroni were used to identify positions with statistically different results. Repeated measurement ANOVA with covariates (such as age, body mass index) or between-subject factors (such as gender) were utilised to identify significant main effects and
Interactions. The analysis was conducted using SPSS for Windows, version 14 (SPSS, Chicago, IL, USA).

**Results**

Of the 26 participants age ranged between 62 and 86 years (mean 73.3; SD = 5.4) 46.2% were female. Mean body mass index was 29.3 kg.m\(^2\) (range 19.1- 49.6 SD = 6.3), with 34.6% of participants describing themselves as moderately active and 65.4% reported they had never smoked and no participant was currently smoking. Overall 42.3% were using anti-hypertensive, 34.6% anti-cholesterol, 19.2% blood thinners, 7.7% HRT and 15.4% NSAID medications. A majority of participants reported sleeping on their sides (right side: 30.8%; left side: 26.9%). Mean values, standard deviations and significant findings for each cardio-respiratory variable and position are reported in Table 1.

[Table 1 about here]

Positions taken during measurements significantly influenced SBP and DBP, RPP and MAP (p<0.001, respectively) as well as SpO\(_2\) (p=0.001; Figure). For both BP measurements and for RPP and MAP, HDS produced the highest mean values. Subsequent paired testing showed that for SBP, HS versus HDS (p<0.001), and all comparisons that were more extreme remained significantly different after Bonferroni adjustment (Figure 1).

[Figure 1 about here]

Multivariate repeated measures ANOVA with covariates and between-subject factors did not reveal any statistically significant interactions. Multivariate repeated measures ANOVA identified no significant difference in any physiological variable when considering anti-hypertensive (HR
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p=0.27, SBP p=0.06, DBP p=0.42, SpO₂ p=0.86, RPP p=0.96, MAP p=0.2) or anti-cholesterol medication (HR p=0.76, SBP p=0.42, DBP p=0.29, SpO₂ p=0.55, RPP p=0.55, MAP p=0.3). Age (negative) and BMI (positive) had significant main effects on resting HR (p=0.023; p=0.012), SBP (p=0.008; p=0.022), DBP (p=0.023; p=0.001), RPP (p=0.001; p=0.002), and MAP (p=0.003; p=0.001). Weight had significant positive main effects on DBP (p=0.009), RPP (p=0.017), and MAP (p=0.006), and negative effects on SpO₂ (p=0.010). Body fat showed positive effects on resting HR (p=0.026) and RPP (p=0.023) and negative effects on SpO₂ (p=0.024).

Discussion

This study has identified significant differences in cardio-respiratory measures in relation to body position in older people. All reported mean values and ranges for all variables in each position, except SpO₂, were within recommended healthy values (see Table 1). Positioning as a means for physiotherapeutic and nursing intervention appear safe for HS, RSL, LSL and S in this population. Head down supine position resulted in the highest BP and RPP readings. Although these variables were still within normal limits care should be taken to monitor BP of people who are hypertensive when placing them in the head down position. Further when placing people with a BMI over 30 in the HDS position HR, RPP and SpO₂ should be monitored. As HDS position increases HR and RPP with average SpO₂ this more extreme position may place an older person at risk of myocardial oxygen insufficiency.
Head down position generally produced the highest mean values for each variable in older people. In contrast highest mean values for each variable occurred in sitting in young healthy people [4]. Lowest values for each variable occurred in LSL or RSL for most variables in both age groups. When considering the highest to lowest values the greatest contrasts in mean values between the young and older people occurred in HR and SpO₂. For ease of comparison previously published young and middle aged results and the results of this study are presented in Table 2. Significant findings are reported and mean values are ranked from highest to lowest with respect to body position.

[Table 2 about here]

Whilst significantly lower HR in relation to body position has been reported in young [4] and middle aged adults [6] this was not found in older people. As well this study found no significant difference in the HR of older people when comparing LSL and RSL. This finding is in agreement with Ryan who reported the same finding in healthy young adults [3]. In contrast Jones & Dean reported significantly lower HR in HS than RSL and in LSL than RSL [4]. Older people recorded the lowest mean value for DBP & SBP in RSL whereas in the young age group this occurred in LSL [4]. More importantly both age groups had significant lower DBP & SBP values in both LSL & RSL compared to sitting and HDS.

It has been postulated that people over the age of 60 years adopt the RSL position for sleep due to age changes in cardio-vascular function [18] or due to discomfort including chest tightness and breathing difficulties in LSL [27]. In this study the greatest percentage of participants (30.8%) reported preference for the right side sleep position and RSL resulted in lower mean SBP, DBP and RPP and higher mean SpO₂ than LSL. However, these differences were not
significant and participants in this study were resting rather than sleeping. Future research should also consider the effect of different positions on the cardiovascular system of the older people population over longer time periods reflective of bed rest.

Of the 26 participants only 6 (23.1%) were not taking any medications. The results found that medications had no significant effect on any of the measures. This may indicate that for the older population positioning will have similar effects regardless of the medications taken. It may also indicate that the medications are effective in stabilising cardio-respiratory function in any body position.

In comparison with the Australian Institute Health and Welfare findings for people over the age of 65 [28] and National Center for Health Statistics, United States findings for people aged 65-85 years the participants of this study were generally less healthy for their age (please see Appendix 2 in the supplementary data on the journal website) [29]. In spite of this no negative effects occurred as a result of this study and during testing participants cardio-respiratory variables remained within the normal range. Although these comparisons indicate the possibility that the findings of this study are generalisable across the older population further research in this area is required.
Conflict of interest

The authors have no conflicts of interest.

Acknowledgement

This research was supported in kind by James Cook University.
Table 1: Comparison of mean (SD) physiological measures across positions. (Highlighted p-values remain significant after Bonferroni adjustment for multiple testing).  

<table>
<thead>
<tr>
<th>Position</th>
<th>Mean (SD)</th>
<th>p-value</th>
<th>SpO₂ (%)</th>
<th>p-value</th>
</tr>
</thead>
</table>
| **HR (beats/min)**  
(n=25)  
70 (50-100) mean (range)  
| RSL  | 60.3 (8.5) | P=0.095 | HS  | 94.4 (2.1) |
| LSL  | 61.0 (9.6) |  | LSL  | 94.6 (2.4) |
| HDS  | 61.4 (9.2) |  | HDS  | 95.1 (2.4) |
| HS  | 61.5 (9.4) |  | RSL  | 95.3 (2.5) |
| Sit  | 63.1 (9.2) |  | Sit  | 95.6 (2.1) |
| **SBP (mmHg) (n=25)**  
95-140 (Normal range)  
| RSL  | 115.2 (10.5) | P<0.001 | RSL  | 7040.0 (1414.1) |
| LSL  | 116.3 (12.2) |  | LSL  | 7048.2 (1271.2) |
| HS  | 118.8 (8.9) | L1 to L3: p=0.037 | HS  | 7315.6 (1414.6) |
| Sit  | 121.0 (11.9) | L1 to L4: p=0.006  
L2 to L4: p=0.020 | Sit  | 7619.3 (1333.5)  
L1 to L4 p=0.005  
L2 to L4 p=0.001 |
| **DBP (mmHg) (n=25)**  
60-90 (normal range)  
| RSL  | 60.2 (9.7) |  | LSL  | 78.1 (9.2) |
| LSL  | 61.3 (11.4) |  | RSL  | 79.5 (10.4) |
| HS  | 65.6 (10.2) | L1 to L3: p=0.005  
L2 to L3: p=0.024 | HS  | 83.2 (8.5)  
L1 to L3: p=0.042  
L2 to L3: p=0.006 |
| Sit  | 69.5 (8.3) | L1 to L4: p<0.001  
L2 to L4: p=0.001  
L3 to L4: p=0.032 | Sit  | 86.7 (8.3)  
L1 to L4: p=0.001  
L2 to L4: p<0.001  
L3 to L4: p=0.026 |
| HDS  | 71.3 (9.5) | L1 to L5: p<0.001  
L2 to L5: p<0.001 | HDS  | 89.8 (9.5)  
L1 to L5: p<0.001  
L2 to L5: p<0.001 |
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Table 2: Ranked mean values and significant differences in cardio-respiratory variables for different age groups. The young age group data is from Jones & Dean unless referenced in the table [2]. LSL = left side lying, RSL = right side lying, HDS = supine with head down, HS = supine, HR = heart rate, SBP = systolic blood pressure, DBP = diastolic blood pressure, SpO\(_2\) = oxygen saturation, RPP = rate pressure product, MAP = mean arterial pressure.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HR</td>
<td>Sit &gt; RSL &gt; HDS &gt; LSL &gt; HS</td>
<td>Sit &gt; HS</td>
<td>Sit &gt; HS &gt; HDS &gt; RSL &gt; LSL</td>
</tr>
<tr>
<td></td>
<td>LSL = RSL = HS [1]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DBP</td>
<td>Sit &gt; HDS &gt; HS &gt; RSL &gt; LSL</td>
<td>Sit &gt; HS&gt; prone</td>
<td>HDS &gt; Sit &gt; HS &gt; LSL &gt; RSL</td>
</tr>
<tr>
<td>SBP</td>
<td>Sit &gt; HS &gt; HDS &gt; RSL &gt; LSL</td>
<td>Sit &gt; HS&gt; prone</td>
<td>HDS &gt; Sit &gt; HS &gt; LSL &gt; RSL</td>
</tr>
<tr>
<td>RPP</td>
<td>Sit &gt; HDS &gt; HS &gt; RSL &gt; LSL</td>
<td>HDS &gt; Sit &gt; HS &gt; LSL &gt; RSL</td>
<td></td>
</tr>
<tr>
<td>SpO(_2)</td>
<td>Sit &gt; HDS &gt; HS &gt; RSL &gt; LSL</td>
<td>Sit &gt; RSL &gt; HDS &gt; LSL &gt; HS</td>
<td></td>
</tr>
</tbody>
</table>

**Significant differences**

<table>
<thead>
<tr>
<th></th>
<th>Young</th>
<th>Middle</th>
<th>Older people</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR</td>
<td>sit &gt; all other positions</td>
<td>RSL &gt; LSL, HS</td>
<td>NSD</td>
</tr>
<tr>
<td></td>
<td>HDS &gt; HS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DBP</td>
<td>LSL &lt; HDS, HS &amp; sit</td>
<td>LSL &lt; HDS &amp; sit</td>
<td>LSL &lt; HDS &amp; sit</td>
</tr>
<tr>
<td></td>
<td>RSL &lt; HDS, HS &amp; sit</td>
<td>RSL &lt; HDS, HS &amp; sit</td>
<td>RSL &lt; HDS, HS &amp; sit</td>
</tr>
<tr>
<td>SBP</td>
<td>LSL &lt; HDS, HS &amp; sit</td>
<td>LSL, RSL &amp; HS &lt; HDS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RSL &lt; HDS, HS &amp; sit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RPP</td>
<td>sit &gt; HDS, HS &amp; RSL</td>
<td>LSL &lt; sit</td>
<td>LSL &lt; sit</td>
</tr>
<tr>
<td></td>
<td>LSL &lt; all other positions</td>
<td>LSL &amp; RSL &lt; HDS</td>
<td></td>
</tr>
<tr>
<td>SpO(_2)</td>
<td>sit &gt; HDS, HS &amp; RSL</td>
<td>LSL &lt; all other positions</td>
<td>Sit &gt; HS</td>
</tr>
<tr>
<td></td>
<td>LSL &lt; all other positions</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Supplementary Data

Appendix 1

Researcher assistant administered questionnaire

Questionnaire

Name: ___________________________ Date of Birth: ___________________________

Activity Level: description of usual weekly activities:

- [ ] Sedentary
- [ ] Slightly active
- [ ] Moderately active
- [ ] Very active

Medication:
Heart condition:

Lung condition:

Other illnesses/conditions

Recent illnesses last 2 weeks:

☐ Flu like symptoms
☐ Shortness of breath

☐ Cough

☐ Wheeze

Position of sleep: (please fill in form 1 if available)

For what reason do you believe you sleep in this position?

How many pillows do you sleep on?

For what reason do you believe you use that amount of pillows?
Smoking History (please fill in form 1 if available)

1. Please circle the position in which you prefer to sleep.

Left side  right side  back  tummy  upright  varies

2. Do you have any medical condition which affect your heart or lungs?  YES/NO

3. Do you currently smoke?  YES/NO

How many cigarettes/cigars/pipes would you smoke per day? .............................................

4. Have you smoked in the past?  YES/NO

If so when did you cease smoking? .................................................................

Left  □  or right  □  handed?

Patient completed questionnaire
When you smoked how many cigarettes/cigars/pipes did you smoke per day?............

5. Do you have any physical or medical condition which would prevent you from comfortably lying on your right side for 20 minutes? YES/NO

6. Do you have any physical or medical condition which would prevent you from comfortably lying on your left side for 20 minutes? YES/NO

7. Do you have any physical or medical condition which would prevent you from comfortably sitting for 20 minutes? YES/NO

8. Do you have any physical or medical condition which would prevent you from comfortably lying on your back for 20 minutes? YES/NO

9. Do you have any physical or medical condition which would prevent you from comfortably lying on your back with your body tilted down for 20 minutes? YES/NO
Appendix 2

Description of study participants (n=26) in comparison to The Australian Institute of Health and Welfare and the National Centre for Health Statistics, USA.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Current study</th>
<th>AIHW (&gt;65 years)</th>
<th>Health US (65-85 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean body mass index (SD); range</td>
<td>29.3 (6.3); 19.1 – 49.6</td>
<td>20.1</td>
<td>28.1</td>
</tr>
<tr>
<td>[kg/m²]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% With diabetes mellitus</td>
<td>7.7% (n=2)</td>
<td>13.7</td>
<td>4.4</td>
</tr>
<tr>
<td>% With osteoporosis</td>
<td>15.4% (n=4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% With reflux symptoms</td>
<td>7.7% (n=2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% With gout</td>
<td>15.4% (n=4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% With respiratory problems</td>
<td>7.7% (n=2)</td>
<td>0.7</td>
<td>3.4</td>
</tr>
<tr>
<td>% With heart condition</td>
<td>38.5% (n=10)</td>
<td>15.7</td>
<td>12.5</td>
</tr>
<tr>
<td>% With lung condition</td>
<td>15.4% (n=4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% With arthritis (% With orthopaedic surgery)</td>
<td>30.8% (n=10)</td>
<td>1.4</td>
<td>15.3</td>
</tr>
<tr>
<td>% With neurological symptoms</td>
<td>7.7% (n=2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% With cancer</td>
<td>11.5% (n=3)</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>% With other condition</td>
<td>30.8% (n=8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% With recent illness</td>
<td>3.8% (n=1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Smoke</td>
<td>0%</td>
<td>7.9</td>
<td>10.4</td>
</tr>
</tbody>
</table>

*SIG = standard deviation
Legend to the Figures

Figure 1: Bar chart (mean and standard deviation) of physiological characteristics (average of repeated measures taken per person) considered for five different positions. P-values comparing all five positions (dotted lines) and p-values comparing two positions (full lines) are given. The p-values comparing two positions are given only when significant after adjustment for multiple testing.

Original values are averages per person over 5 or 10 (head down) repeated measurements.
References


Body position and cardio-respiratory variables in older people


Body position and cardio-respiratory variables in older people


21. Nonin Onyx 9500 Medical Nonin Medical, Inc.13700 1st Avenue North, Plymouth, Minnesota. 55441-5443 USA. Toll Free: 1.800.356.8874 (USA and Canada). Phone: +1.763.553.9968. Fax: +1.763.553.7807

22. Spirit majestic stethoscope. Spirit Medical UK, Unit 1 Invicta Business Park, London Road, Wrotham. Kent. UK. TN15 7RJ. Phone: 0845 869 3113


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