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Breathing Television: A Breathing Controlled Multimedia Player for Reducing Breathing Rate

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Abstract

We have designed a breathing paced television; a television that plays content in sync with users' activity of exhaling through pursed lips, to achieve better motivation and compliance of such exercises. Described system has been tested with control group who have watched the same video. Breathing rate reduction was significantly higher in active group (54.48% ± 8.34%) than in control group (6.84% ± 17.21%), however, the proposed method of watching television is obviously not as trivial as watching television *per se*.

Keywords

Breathing Television, Breathing Rate Reduction, Pursed Lip Breathing, Pulmonary Rehabilitation

1. Introduction

Pursed lip breathing is a well-known technique in pulmonary rehabilitation, which reduces breathing rate and makes breathing more efficient [1]-[4]. Television has emerged into an efficient multimedia distribution platform, yet it is shown to disturb breathing and consequently increasing their breathing rate [5]-[9]. Increased breathing rate is often correlated with progression of various diseases [10] [11] and can be observed especially in anxiety and panic attacks [12]-[14]. In both western and eastern medical practice, reducing breathing rate has proven to be an efficient health improving method [15]-[18]. Breathing rate reduction is most often achieved by exhalation through pursed lips, commonly referred to pursed lip breathing (PLB). Exhalation through pursed lips creates resistance during exhalation which prolongs exhalation and allows more air to come out of the body [19]-[24]. PLB exercises are mainly delivered at care-giving levels such as nursing, post-operative care and respiratory physiotherapy care. In clinical environment such exercises are provided through the respiratory therapist or in written instructions as well (**Figure 1**).

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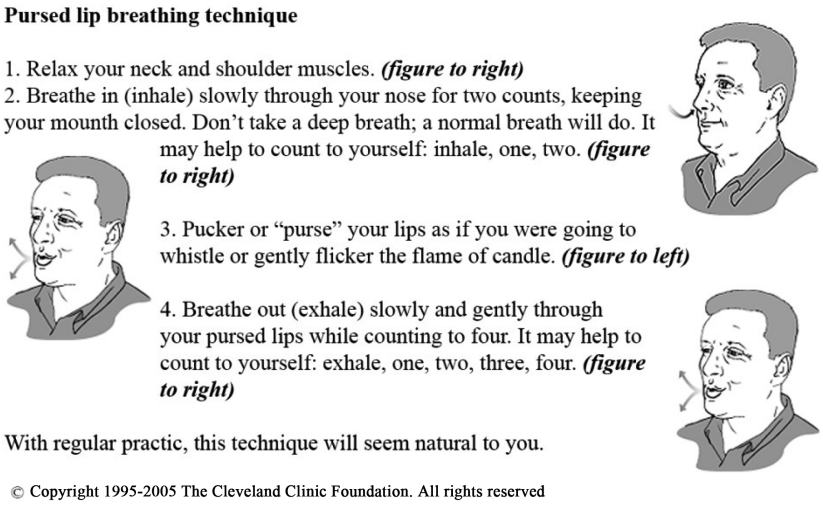

Pursed lip breathing technique

1. Relax your neck and shoulder muscles. ***(figure to right)***
2. Breathe in (inhale) slowly through your nose for two counts, keeping your mouth closed. Don't take a deep breath; a normal breath will do. It may help to count to yourself: inhale, one, two. ***(figure to right)***

3. Pucker or "purse" your lips as if you were going to whistle or gently flicker the flame of candle. ***(figure to left)***

4. Breathe out (exhale) slowly and gently through your pursed lips while counting to four. It may help to count to yourself: exhale, one, two, three, four. ***(figure to right)***

With regular practic, this technique will seem natural to you.

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Figure 1. Pursed lip breathing instructions as provided by Cleveland Clinic Foundation.

Our goal is to design a breathing paced television in a way to most efficiently reduce users' breathing rate and also allow users to control television content. It will help to motivate patients to perform breathing exercises and bring a new point of interaction in entertainment, gaming and education applications as well.

2. Materials and Methods

To detect exhalation through pursed lips, a microphone equipped headset was used [25]-[27]. Breathing controlled television was designed using *Adobe Flash* and YouTube API with the following algorithm (**Figure 2**).

This algorithm was implemented using the following Actionscript code:

```
//initiate microphone
var microphone: Microphone = Microphone.getMicrophone();
microphone.setSilenceLevel(30, 5);
microphone.setLoopBack(true);

//sound transform, set volume to 0
var myTransform:SoundTransform = new SoundTransform(0);
microphone.soundTransform = myTransform;

//add listener
microphone.addEventListener(ActivityEvent.ACTIVITY, activityHandler); ---------->exhalation detector

//read mic activity
function activityHandler(event:ActivityEvent):void {
    //begining of exhale
    if(event.activating){          ---------->exhalation start detected
        if(player != null){
            player.playVideo(); ----------> PLAY
        }
    }
    //end of exhale
    else{          ---------->exhalation end detected
        if(player != null){
            player.pauseVideo(); ---------->PAUSE
        }
    }
}
```

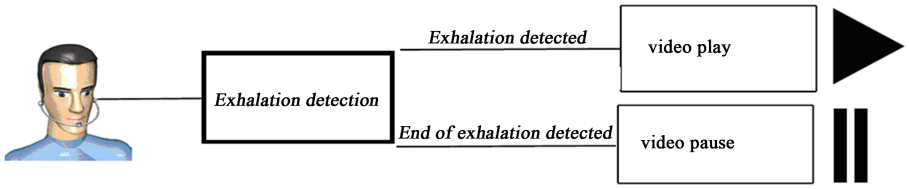

Figure 2. Breathing television, algorithm realized with YouTube API and Actionscript 3.0.

When exhalation through pursed lips is detected, a video playback begins. It stops as soon as exhalation is not detected anymore.

Clinical trial was approved by Medical Ethics Committee of Slovenia on February 12th 2013. There were 51 healthy adults involved in a trial, who were randomly arranged into two groups. An image (**Figure 3**) was shown to all volunteers to apply the headset correctly.

First group (active group, 26 subjects) were watching a YouTube video (Psy: Gangnam style, length 4:13) which started and paused according to their activity of exhaling through pursed lips as described above. The second group (control group, 25 subjects) were watching the same YouTube video which was playing even though their breathing was incorrect. Breathing rate of both groups was acquired by a sensor measuring expansion of abdomen. After that a value of breaths-per-minute (BPM) was calculated with the *Mindmedia Nexus* 10 computer software. Breathing rate before and after watching a video was measured in both groups.

3. Results

Breathing rate reduction was calculated as a normalised difference between breathing rate in the beginning and at the end of the video, results are shown in **Table 1**.

To compare breathing rate reduction between groups, we have calculated a mean value, standard deviation and variance of breathing rate reduction in percentages for each group (**Figure 4**).

Group	N	Mean	Std. deviation	Variance
A	26	54.480055243197	8.3410678330790	69,573
C	25	6.847228678118	17.2122591803222	296,262
Total	51	31.130630456393	27.4833756056068	755,336

To test significant difference between groups, we have observed how breathing rate reduction is normally distributed, see **Figure 5**.

To see if the normal distribution is in place, we have used Levene's test for variance and t-test to observe significance of difference between groups.

Independent samples test						
		Levene's test for equality of variances		t-test for equality of means		
			Sig.	t	df	Sig. (2-tailed)
BRR	**Equal variances assumed**	13.227	0.001	12.654	49	0.000
	Equal variances not assumed			12.498	34.380	0.000

Because significance of t-test is lower than 0.05, the difference between active and control groups is statistically significant.

4. Conclusion

Breathing rate reduction was significantly higher in active group (54.48% ± 8.34%) than in control group (6.84% ± 17.21%). Although the proposed method of watching television content is obviously not as ordinary as watching television by itself.

Table 1. Breathing rate reduction.

Volunteer no.	Group (A = active, C = control)	BR before	BR after	BR reduction (absolute)	BR reduction (relative)	BR reduction (%)
1	A	5.2	3.1	2.1	0.403846153846154	40.3846153846154
2	A	4.1	1.9	2.2	0.536585365853659	53.6585365853659
3	C	8	7.8	0.2	0.025	2.5
4	C	8.1	7.3	0.8	0.098765432098765	9.87654320987654
5	C	5.2	6.1	−0.9	−0.173076923076923	−17.3076923076923
6	A	4.6	2.1	2.5	0.543478260869565	54.3478260869565
7	A	4.1	1.4	2.7	0.658536585365854	65.8536585365854
8	C	10.8	9.4	1.4	0.12962962962963	12.962962962963
9	C	5.7	6.2	−0.5	−0.087719298245614	−8.7719298245614
10	A	8.1	3.1	5	0.617283950617284	61.7283950617284
11	A	9.5	3.8	5.7	0.6	60
12	A	7	2.5	4.5	0.642857142857143	64.2857142857143
13	A	6.3	2.6	3.7	0.587301587301587	58.7301587301587
14	A	5	1.9	3.1	0.62	62
15	A	9.1	4.6	4.5	0.494505494505494	49.4505494505494
16	A	10.9	3.7	7.2	0.660550458715596	66.0550458715596
17	A	14	7.1	6.9	0.492857142857143	49.2857142857143
18	A	8.2	3.6	4.6	0.560975609756098	56.0975609756098
19	C	7.9	6.1	1.8	0.227848101265823	22.7848101265823
20	C	5.1	6.2	−1.1	−0.215686274509804	−21.5686274509804
21	C	5.7	4.2	1.5	0.263157894736842	26.3157894736842
22	C	14.2	10.6	3.6	0.253521126760563	25.3521126760563
23	C	6.8	6.1	0.7	0.102941176470588	10.2941176470588
24	C	6.2	7	−0.8	−0.129032258064516	−12.9032258064516
25	C	9.2	7.3	1.9	0.206521739130435	20.6521739130435
26	C	4.8	4.7	0.1	0.020833333333333	2.08333333333333
27	C	4.4	5.5	−1.1	−0.25	−25
28	A	9.2	6.1	3.1	0.33695652173913	33.695652173913
29	A	9.8	4.1	5.7	0.581632653061225	58.1632653061224
30	A	7	3.8	3.2	0.457142857142857	45.7142857142857

Continued

31	A	9.9	5.1	4.8	0.484848484848485	48.4848484848485
32	A	12	6.2	5.8	0.483333333333333	48.3333333333333
33	A	6.4	2.8	3.6	0.5625	56.25
34	A	7.3	2.7	4.6	0.63013698630137	63.013698630137
35	A	7.9	4.1	3.8	0.481012658227848	48.1012658227848
36	A	13.1	6.1	7	0.534351145038168	53.4351145038168
37	A	6.2	2	4.2	0.67741935483871	67.741935483871
38	A	6.9	3.1	3.8	0.550724637681159	55.0724637681159
39	A	5.9	3	2.9	0.491525423728814	49.1525423728814
40	A	13.7	7.2	6.5	0.474452554744526	47.4452554744526
41	C	10	7.4	2.6	0.26	26
42	C	11.5	9	2.5	0.217391304347826	21.7391304347826
43	C	8.4	9	−0.6	−0.071428571428571	−7.14285714285714
44	C	7.3	6.9	0.399999999999999	0.054794520547945	5.47945205479451
45	C	9.3	10	−0.699999999999999	−0.075268817204301	−7.5268817204301
46	C	9.1	5.3	3.8	0.417582417582418	41.7582417582418
47	C	7.8	7.6	0.2	0.025641025641026	2.56410256410257
48	C	9.3	10	−0.699999999999999	−0.075268817204301	−7.5268817204301
49	C	12	9.2	2.8	0.233333333333333	23.3333333333333
50	C	10.3	9.4	0.9	0.087378640776699	8.73786407766991
51	C	9.7	8.1	1.6	0.164948453608247	16.4948453608247

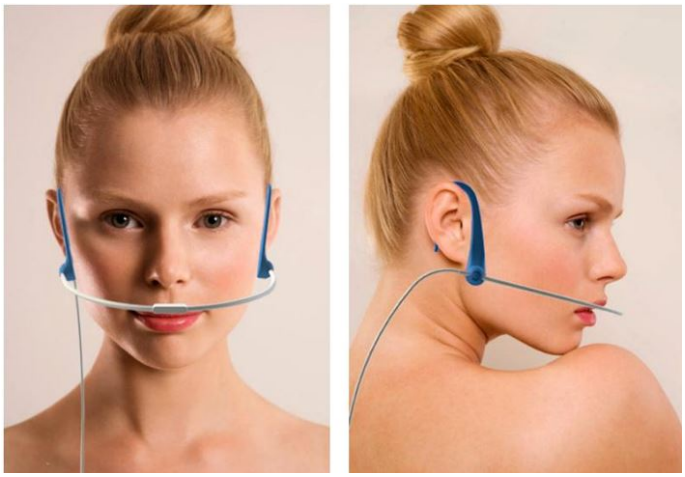

Figure 3. Image shown to volunteers to apply the headset correctly.

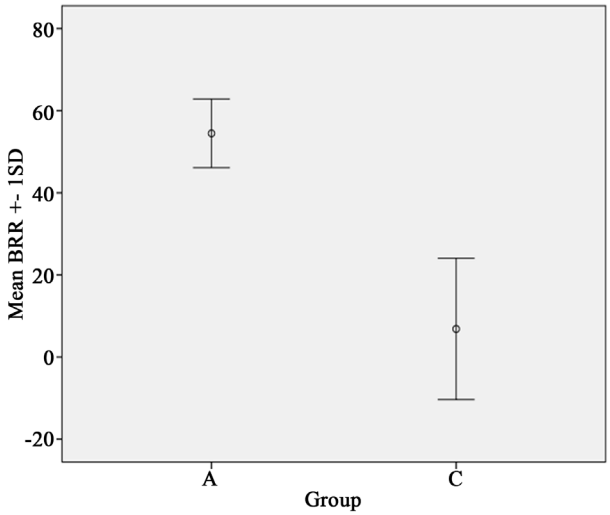

Figure 4. Standard deviation and variance for active (A) and control (C) group.

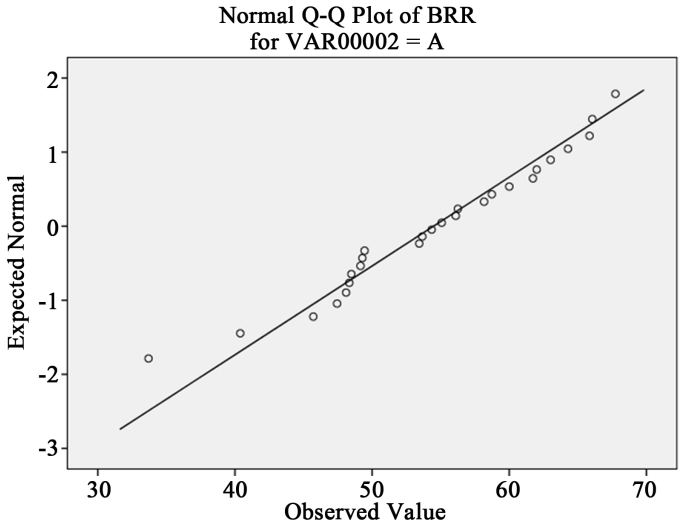

Figure 5. Distribution of breathing rate reduction.

5. Discussion

Breathing rate reduction in active group is enormously bigger then in control group. It is important to know that the exhalation through pursed lips can lasts a lot longer than exhalation through nose (it reduces breathing rate enormously).

Because video in active group was controlled by user's breathing, it lasted approximately 30% longer than in control group where it was played continuously. Consequently intervention in active group lasted longer which may have contributed to breathing rate reduction.

Breathing controlled television is efficient in reducing breathing rate, however it requires continuous activation of a video. Because playing is executed with user's exhalation, the system is not as comfortable as normal television.

The video (*Psy*: *Gangnam style*) was chosen due to its popularity, which decreases cognitive effort of a video. Therefore it may have resulted in surprisingly efficient BRR in control group as can be observed in our data. We suppose that improvement of BRR would be even better in an experiment, if volunteers were watching a video that requires more cognitive effort.

Declaration of Interest

Matevz Leskovsek, PhD, is a partner at BREATHINGLABS.COM, a company that produces human computer interfaces for breathing exercises, breathing games, and breathing entertainment. Other authors declare no competing interests.

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