Cycle Ergometer and Rebound Exercises with Chest Physiotherapy - a Useful Adjunct for Sputum Expectoration in Mild to Moderately Symptomatic HIV Infected Children.

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ABSTRACT: Background: *Sputum expectoration of lung secretions in HIV infected children with associated respiratory conditions is often difficult. Chest physiotherapy is often recommended to assist in this process but is not always successful. Aerobic exercises may have beneficial effects on sputum expectoration but its safety is uncertain.*

Aim: *The primary aim of this study was to determine if cycle ergometer and rebound exercises are safe for mild to moderately symptomatic HIV infected children and if these aerobic exercises followed by chest physiotherapy could augment sputum expectoration.*

Method: *Thirty six African 8-12 year old males performed 15 minutes of either cycle ergometer or rebound exercises. A modified 6 minute walking test to ensure fitness of the enrolled subjects prior to randomization was performed. Heart and respiratory rates, blood pressure and oxygen saturation was monitored for safety. Sputum expectorated was measured in a calibrated vial at baseline, 5, 10, and 15 minutes post exercise followed by 30 minutes of conventional chest physiotherapy.*

Results: *Total sputum produced during and post rebounding exercise was significantly higher than cycle ergometer exercises (12.6 vs. 9.8mls p=0.0002). The quantity of sputum obtained over each time point after rebound exercise was significantly more than cycle ergometer (5, 10 & 15 minutes; p=0.0084, p= 0.0002, p=0.0002 respectively). There were no significant differences in heart and respiratory rates, blood pressure and oxygen saturation of enrolled subjects between these exercises and no cases reached the threshold for stopping the exercise.*

Conclusion: *Cycle ergometer and rebound exercises are safe for mild to moderately symptomatic HIV infected children. Rebound exercises followed by chest physiotherapy can be used as a safe adjunct to significantly increase sputum expectoration.*

KEYWORDS: REBOUND EXERCISE, CYCLE ERGOMETER, EXPECTORATION, MODERATELY SYMPTOMATIC, HIV INFECTED CHILDREN

INTRODUCTION

The Human Immune-deficiency Virus (HIV) suppresses the immune system and makes its host susceptible to opportunistic chest infections. The thick mucus that is produced causes airway obstruction, sets up a breeding ground for bacterial infection and leads to an irreversible loss of pulmonary function (Jeena 2000). The child presents with fatigue and dyspnoea resulting in poor exercise capacity and the inability to perform simple activities of daily living and this has a profound impact on the quality of life (McGavin et al 1978). The effect of chronic respiratory limitations due to ventilatory adaptations alters lung volumes and capacities, increasing tidal volume and minute ventilation and reduces cardiopulmonary fitness at rest and during low intensity daily activities. These children develop a sedentary lifestyle with a decrease capacity for aerobic exercise leading to hyperventilation which perpetuates cardiopulmonary compromise resulting in a dyspnoea spiral (Prefaut et al 1995).

In order to improve lung function the child is often referred for chest physiotherapy to remove excess secretions and obtain sputum samples for laboratory culture. The procedure of chest physiotherapy entails postural drainage coupled with coughing, percussions and vibrations. Patients are positioned into gravity assisted postures based on the anatomy of the bronchial tree to allow secretions to be loosened and cleared from airway walls. Following this procedure tenacious thick secretions are removed thus optimizing bronchial hygiene, improving ventilation and cardiopulmonary function, slowing the proteolytic destruction of airways and

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generally reducing the risk of secondary chest infections (Pryor & Webber 1999).

In the normal population regular exercise may partially replace conventional chest physiotherapy (Zach et al 1982; Andreasson et al 1987) as aerobic exercises have positive effects on cardiopulmonary function. There is limited data showing the beneficial effects of exercise on sputum expectoration in HIV infected children with associated lung disease. Stringer (1999) noted that the participation in specific and regular exercise programs is known to improve immune function and the quality of life of an HIV infected individual with positive effects on lung function, breathing and ventilation. This augments a better physical and emotional status and delays AIDS-related complications (McClure 1993). Aerobic capacity is however substantially reduced in physically inactive adolescents with HIV infection compared to age-matched sedentary controls (Cade et al 2002). Furthermore the prescription of exercises in HIV infected children using conventional heart rate and oxygen uptake (VO_2) analog can be problematic due to errors in heart rate monitoring and technical complexity of respiratory-metabolic assessment in children, as they are physically different from adults having higher heart rates during rest and exercises (Cheatham et al 2000).

There is therefore a need to determine which exercises could be safe and beneficial for HIV infected children with associated lung disease. Therefore the primary aim of this study was to determine whether cycle ergometer or rebound exercises were safe for use in mild to moderately symptomatic HIV infected children and the concomitant effect on the volume of sputum expectorated.

METHOD

Ethical approval

Informed consent was obtained from the child's parents as approved by the King Edward VIII hospital board and the University of KwaZulu-Natal ethical review committee.

Subjects

Forty HIV infected 8-12 year old African boys referred for chest physiotherapy and sputum samples from the paediatric respiratory clinic of King Edward VIII hospital were enrolled into the study. Gender and age bias was related to physiological and biological changes that are known to occur during this period. Alveolar development begins in fetal life and matures at around 8 years with boy's peak VO_2 values significantly higher than girls before puberty (Armstrong et al 1995).

Inclusion Criteria

This was based on WHO HIV and CDC HIV grading systems:

- Children with WHO stage 2 or 3 disease or CDC category A or B with mild-moderately symptomatic HIV infection were enrolled. The presenting diagnoses of these children were acute (pneumonia) on chronic infected lung disease (LIP,TB, Bronchiectasis)
- As a safety precaution completion of the six minute walking test as prescribed by the American Thoracic Society (2002) was required. Children were monitored with heart and blood pressure monitoring at three time points viz. 0, 3 and 6 minutes.

Exclusion Criteria

The child was excluded if:

- he could not interpret or communicate effectively
- there was reluctance to perform the required exercise

Table 1: Baseline Characteristics

Characteristics Mean ±SD	Bicycle Ergometer Mean ±SD	Rebound Exercise Mean ±SD	p-value
Age (yr)	10.1 (8-12)	9.8 (8.1-11.9)	Ns
Body Mass (kg)	35.3 ± 8.2	36.5 ± 6.0	ns
Body Height(cm)	145.8 ± 6.9	142.2 ± 7.6	ns
Thigh Length (cm)	35.2 ± 1.9	34.6 ± 2.4	ns
Leg Length(cm)	13.1 ± 1.4	12.5 ± 1.1	ns
Foot Length(cm)	33.9 ± 1.7	32.5 ± 2.1	ns
CDC HIV status A	3	2	ns
B	15	16	ns
WHO Categories 11	2	3	ns
111	16	15	ns
Respiratory Rate(min)	28	31	ns
Heart Rate (beat/min)	81	79	ns
Blood Pressure (mm/Hg)- prior to walking test	121/67	126/73	ns
Sputum (ml)	0.9	1.1	ns

Table 2: Sputum Production at different time points per exercise performed

Time (min)	Cycle Ergometer Sputum (ml) Mean ± range	Rebound Exercise Sputum (ml) Mean ± range	p-value
0	0.89 (0.5-1.3)	1.10(0.6-1.8)	Ns
5	1.41 (0.7-2.1)	1.91(1.3-2.6)	P=0.0084
10	2.10 (1.3-2.7)	3.13(2.4-4.0)	P= 0.0002
15	2.30 (1.8-3.0)	3.83(3.1-4.8)	p = 0.0002
30	3.10 (2.6-3.7)	2.74(2.0-3.6)	ns
Accumulative	9.80 (8.3-11.1)	12.6(10.7-13.9)	p = 0.0002

Table 3: Blood Pressure recordings (mm/Hg)

	Cycle Ergometer	Rebound Exercise
Rest (post walking test)	131/77	136/83
5mins	141/85	148/91
10mins	144/82	135/88
15mins	146/87	146/91

Procedure

On completion of the walking tests the subjects rested for thirty minutes during which they were randomly and equally assigned by a computer into two groups.

Group A

These children cycled on the Monark Model 1818 ergometer with movable handle bars and set with a pedal rate of 60 revolutions per minute and no resistance.

Group B

Performed two feet bouncing on a mini-trampoline Model T-rebound with 36 springs and a circumference of 1metre fitted with handle bars for safety. The bounce frequency was a minimum of 60 per minute with a height of 10cm.

The following descriptive characteristics and measurements were taken and averaged for the subjects in the respective groups (table 1).

Measurements

The body mass, height, thigh length, leg length and foot length of all subjects were measured. All measurements were done without shoes. The subject's mass was measured on a balance beam scale and height was measured using a wall-mounted stadiometer. Thigh length was measured from the greater trochanter to the lateral femoral condyle. Leg length was measured from the lateral femoral condyle to the lateral malleolus and foot length was measured from the lateral malleolus to the fifth metatarsal head.

Exercise Procedure

Each child was familiarized with the respective exercise. Before commencement (and during) the exercises, heart and respiratory rates, blood pressure and oxygen saturation was monitored and recorded using a portable Datex-Ohmeda Cardiocap 5 which was tested and calibrated by a technician. The child was encouraged to cough out sputum into a calibrated vial. All these values were recorded as the resting values.

Completion of a successful revolution or bounce was signaled by an electronic metronome. Both groups had five minute of the respective exercise alternating with 3 minutes of rest. This was repeated three times with the heart and respiratory rates, oxygen saturation and blood pressure being continuously monitored and recorded at 5, 10 and 15 minutes respectively. As a safety precaution heart rate maximum was set at within 10 beats of 80% of age predicted (220-age) maximum (American College of Sports Medicine 1995). Sputum expectorated was also recorded at these time points. Throughout the exercise period the researchers monitored for subjective fatigue, dyspnoea and respiratory distress, profuse sweating, an inability to maintain the desired exercise intensity or unsteady gait which were used to as a threshold to indicate that the child was approaching or reached his maximum exertion (Rowland et al 1990). A 25% increase in systolic and diastolic blood pressure above resting blood pressure during exercise was regarded as an indication for stopping the activity (Lim et al 1996).

On completing the exercise the child rested for 3 minutes followed by chest physiotherapy performed by a senior physiotherapist who was blinded to the type of exercise. The child assumed six postural drainage positions. In each position the chest wall was percussed for 5 minutes followed by deep-breathing exercises combined with vibration on expiration, forced expirations and vigorous coughing. Completion for all drainage positions required approximately 30 minutes and conformed to international standards for chest physiotherapy as prescribed by McIlwaine et al (1997). Post-chest physiotherapy the total volume of sputum expectorated was recorded.

Statistical Analysis

All data was analyzed with SPSS 11.5 for windows (SPSS Inc Chicago, IL). Descriptive analyses were preformed using Student t-test for continuous variables and Chi-squared and Fisher exact test for categorical variables. Two tailed p values of $p < 0.05$ were considered statistically significant.

RESULTS

Two children did not complete the walking test. One child felt nausea during rebound exercise and another did not complete cycle ergometry due to pain experienced in his right knee. A total of 36 children completed the study and all values depicted and tabulated are the mean for the subjects in the relevant areas.

Physical Characteristics

The descriptive characteristics and measurements of subjects in both exercise groups are tabulated in table 1. Age, body mass, body height, thigh, leg and foot length did not differ significantly between the groups.

Oxygen Saturation, Heart and Respiratory Rates

Mean heart and respiratory rates at rest and during the respective exercises did not differ significantly between the groups (figure 1 and 2). The average heart and respiratory rates that were attained were within the average rates for normal children performing aerobic exercises. Oxygen saturation did not differ significantly between the groups (figure 3).

Blood Pressure

No significant differences existed between the groups however children in both groups appear to be in the hypertensive range before commencement of the exercises (table 3) and remained high during cycle ergometry with erratic readings occurring during rebound exercise as compared to normal children in this age group.

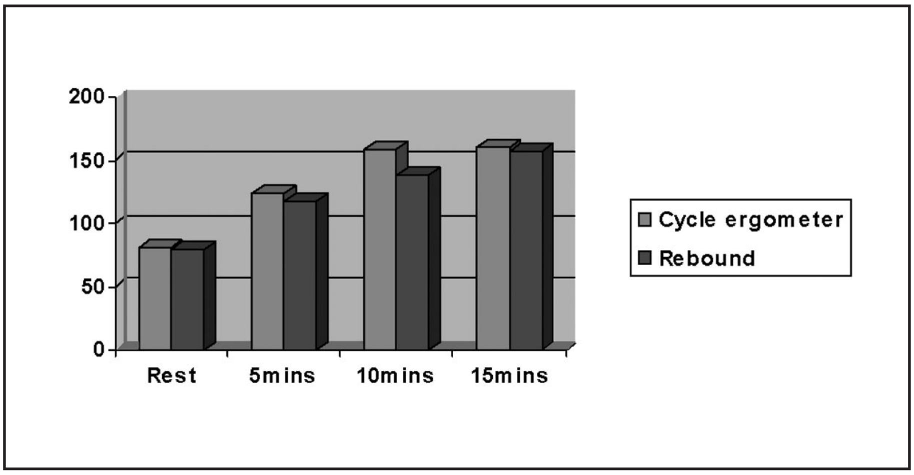
Sputum Volume

Average sputum volumes for the groups were high at all points (figure 4). Post-chest physiotherapy the cycle ergometer group produced a total of 9.8ml and rebound exercise 12.6ml. The sputum volume produced at 10 minutes of rebound exercise was equivalent to that produced by 15minutes of cycling 6,1mls vs 6.7mls respectively.

DISCUSSION

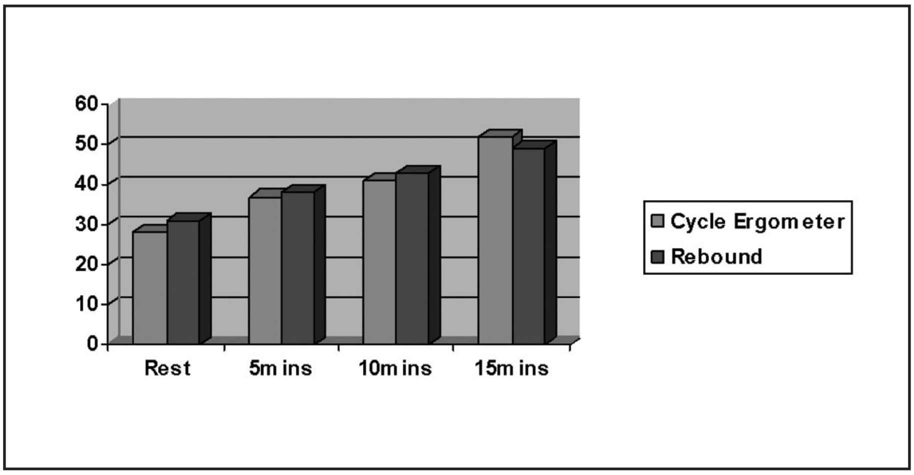
Although all the enrolled subjects presented with cardiopulmonary compromise secondary to HIV related lung diseases, ninety percent completed the exercises without compromising their health status; indicating that aerobic

Figure 1: Heart rate (beats/min)



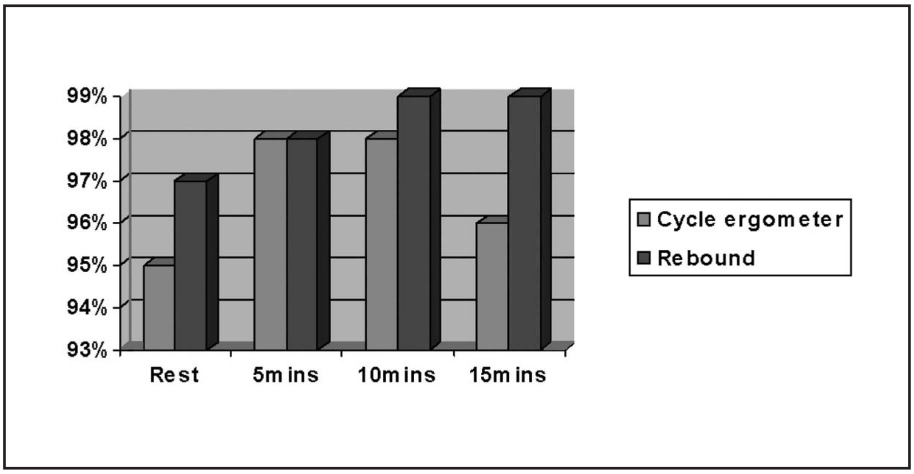
Rest	5	10	15 min	Rest	5	10	15 min
81 b/min	124	159	161	79	118	138	157
(75-89)	(105-132)	(149-168)	(150-168)	(70-84)	(88-130)	(130-144)	(147-166)

Figure 2: Respiratory rate (per minute)



Rest	5	10	15 min	Rest	5	10	15 min
28	37	41	52	31	38	43	49
(20-36)	(35-46)	(36-48)	(47-59)	(22-39)	(35-44)	(38-48)	(44-56)

Figure 3: Oxygen Saturation (%)



Rest	5	10	15 min	Rest	5	10	15 min
95%	98%	98%	96%	97%	98%	99%	99%

exercises is safe to perform in the short term. Dyspnoea is probably the most prominent of the varied sensations that prevent athletes, untrained individuals and patients with cardiopulmonary disorders from exercising (Jones 1984). When exercising, these individual hyperventilate to compensate for the increased workload with a shortened inspiratory time which shortens and flattens the diaphragm's force of production (Poole et al 1997). Both exercises in this study showed an increase in respiratory rates. The repetitive bouncing movements of the rebounder probably enhanced diaphragm movements with a concomitant effect on the force of sputum production. The elastic nature of the lung together with whole body movements increases the recoil pressure of the lungs and enables trapped sputum to be expectorated. Exercise and eucapnic hyperventilation accelerate mucociliary transport (Wolff 1977). The rebounding effect augments oscillation of airflow which enhances the loosening of mucus from the airway walls. Coupled with the movement of the diaphragm which is enhanced by gravity, the overall effect is similar, albeit more effective, than the active cycle of breathing techniques which has been shown to improve both clearance of broncho-pulmonary secretions and lung function (Pryor & Webber 1999).

In this study both cycle ergometer and rebound exercises had beneficial effects on sputum production because both activities augment the active cycle of the breathing technique which is effective in sitting or standing. The active cycle of breathing may be performed with or without a physiotherapist providing vibration, percussion and shaking. With ergometer exercise, the sitting posture and the rhythmical movement of the lower limbs augment diaphragm movements while with rebound exercise the movement of the diaphragm, lungs and inspiratory and expiratory muscles is subjected to the rhythmical action of gravity. It is this rhythmical gravity assisted force that has an enhanced positive effect on the respiratory system, the loosing of secretions and the facilitation of the movement of these secretions. This could explain the significant increase in sputum volume in rebounding as compared to cycling. Furthermore, children in this study enjoyed participating in either of the two physical activities and regular performance of these safe activities could alter the dyspnoea spiral to allow reversal of deconditioned cardiopulmonary system. These results are similar to that observed by Salh et al (1989) in which physiotherapy and a safe home program of exercise increased sputum expectoration in patients with cystic fibrosis suggesting that exercise should be used to augment rather than replace conventional chest physiotherapy.

Blood pressure monitoring during exercise can be used to limit exercise in heart or lung disease with an increase of 25% above baseline being used as a cutoff. The hypertensive readings at rest prior to randomization to cycling or rebound could be related to the walking tests that the children performed.

Olsen et al (2002) found that systolic blood pressure increase with exercise time, reaches a peak at 12 minutes at a heart rate of 160 beats per minute with diastolic pressure remaining constant throughout the exercise. During this study the cycle ergometer group seems to confirm these findings but the erratic and fluctuating blood pressure noted with rebound exercise is probably due to the nature of the effects of gravity on our readings. Also with rebounding the use of fluctuating positive and negative lower body positions correlates to changes in central and thoracic blood volumes which results in predictable changes in central venous pressure (Coast et al 1998). On comparison therefore cycling has a more localized hyperaemia whereas rebounding exercises has a more general effect on circulation thus accounting for a slightly higher than normal blood pressure readings between these two modes of exercises.

CONCLUSION

The results of this study indicated that rebound exercise and cycling on the bicycle ergometer are safe exercises for mild to moderately symptomatic HIV infected children. Rebound exercise produced a larger volume of sputum in a shorter period of time when compared to cycle ergometry. Rebound exercises therefore appears to mobilize peripheral lung secretions more effectively than cycle ergometry and can be used to significantly enhance sputum expectoration as an adjunct to conventional chest physiotherapy.

LIMITATIONS TO THE STUDY

The inclusion criteria did not take into account the child's previous exposure to cycle ergometer or rebounding activity before being assigned to the groups. Although the researchers motivated subjects to cough up all secretions, some secretions could have been swallowed or saliva could have been included in the sample thereby affecting the sputum volumes but these would be represented in both arms of the study. Dried sputum mass was not undertaken in this study.

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