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Comparative Study of Cold Spinal Spray on Respiratory Functions among Normal BMI Individuals and Obese Individuals

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Abstract: ***Background: Cold spinal spray (CSS) is a commonly used hydrotherapeutic measure by the Naturopathic physicians for many cases. This study was done to find the effect of cold spinal spray on respiratory functions using spirometry in healthy individuals and obese individuals. Methods: Sixty subjects of age 24.43±2.52 years were classified into obese and non - obese groups based on their Body mass index. Subjects with BMI 18.5 to 24.9 kg/m^2 and 30 - 39.9 kg/m^2 were recruited in the non - obese and obese groups respectively.15 males and females each were recruited in both the groups. Results: Analysis of variance for between group changes adjusted for their respective baseline values and post - hoc Bonferroni test for multiple correction demonstrated a significant reduction of respiratory rate [F (1, 57) =14.77, p≤0.0005, pŋ^2=0.206], diastolic blood pressure [F (1, 57=8.097, p=0.006, pŋ^2=0.124], pulse rate [F (1, 57) =61.214, p≤0.0005, pŋ^2=0.518] in the non - obese group as compared to the obese group. Also, a significant increase in FVC, FEV1/FVC [F (1, 57=7.83, p=0.007, pŋ^2=0.121)] were observed in non - obese group. Interpretation and Conclusion: Cold spinal spray improves the respiratory functions of the healthy individuals comparing to the obesity individuals.***

Keywords: Hydrotherapy, Cold spinal spray, Respiratory functions, Obesity

1. Introduction

Breathing which is an essential life - sustaining activity requires the contraction of respiratory muscles which is mainly coordinated by the respiratory motor control system and healthily integrates input from the brain, spinal cord, brainstem and peripheral nerves [1] Respiratory muscles are skeletal muscles whose primary role is to rhythmically displace the chest wall to inhale air rich with oxygen and to exhale air with high content of carbon dioxide. Actions and innervations of the inspiratory respiratory muscles and expiratory respiratory muscles shows the relation of spinal nerves in relation with the respiratory system and its functions. The final common path for motor output of the respiratory gate from the central nervous system is the motor unit which is made up of the spinal motor neuron, its axon, neuromuscular junctions, and the muscle fibers it activates which serves the purpose of filling and emptying the lungs [2]

According to WHO (World Health Organization), Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health [3]. The prevalence of obesity has increased dramatically in recent decades. From 1975 to 2014, global rates of obesity i.e. body mass index > 30 kg/m^2 increased from 3.2 to 10.8% in men and from 6.4 to 14.9% in women. In England, in between 1980 and 2013 the numbers of overweight and obese adults increased from 36% to 62%. It is estimated that by 2025, 18% of men and 21% of women worldwide will be obese [4]. By 2030, it is estimated that 38% of the world's population will be overweight and another 20% will be obese. In USA, it is found to be over 85% of adults being overweight or obese by 2030 [5]

Body mass index (BMI) is an estimate of body fat based on height and weight. It doesn't measure body fat directly, but instead uses an equation to make an approximation. BMI can help determine whether a person is at an unhealthy or healthy weight. BMI is calculated by dividing a person's weight by the square of their height. BMI is calculated by dividing weight in kilograms by square of heights in meters. The normal BMI ranges from 18 to 24.9 kg/m2, below 18 kg/m2 is underweight, 25 to 29.9kg/m2 is overweight and more than 30kg/m2 is obese [6]

Obesity is also associated with increased risk for numerous chronic diseases, including diabetes, hypertension, heart disease, stroke, respiratory problems, etc,. Respiratory problems associated with obesity occur when added weight of the chest wall squeezes the lungs and causes restricted breathing.

Obesity has a potential to have a direct effect on respiratory well - being, since it consumes more oxygen and produce more carbon dioxide and at the same time it stiffens the respiratory system and increases the mechanical work needed for breathing [7]

Naturopathy is a distinct type of primary care medicine that blends age - old healing traditions with scientific advances and current research. Naturopathy is guided by a unique set of principles that recognize the body's innate healing capacity, emphasize disease prevention, and encourage individual responsibility to obtain optimal health [8]. Hydrotherapy is the external or internal use of water in any of its forms (water, ice, steam) for health promotion or treatment of various diseases with various temperatures, pressure, duration, methods and site. Use of water in various forms and in various temperatures can produce different effects on different system of the body. Many studies/reviews reported the effects of hydrotherapy only on very few systems and there is lack of studies/reviews in reporting the evidence - based effects of hydrotherapy on various systems. The different methods of hydrotherapy treatments are packs, affusions, sprays, baths, douches, etc, [9]

Out of these methods, spinal spray is taken as intervention for this study. Spinal spray is a local, slightly pressurized (1 pressure per square inch (PSI)) hydratic measure in which the spinal area is exposed to water of certain temperature for a specific duration to get desired effects. This procedure controls all the organs of the body, since most of the nerve roots start from the spinal cord. The small and large blood vessels of the heart, lungs, digestive system and brain contract or dilate depending on the temperature of water used in the spray [10]

The cold spinal spray has both the mechanical and thermal effects of water. This spinal spray treatment with water of cold temperature is extensively indicated in every naturopathy hospitals for various therapeutic conditions related to cardiovascular and respiratory system, this is because prolonged application of cold causes reduction in blood flow and heart rate and the cold application in reaction phase will dilate the blood vessels and reduces the blood pressure which influences the reduction in the rate of respiration with increasing in the depth of respiration.

2. Literature Review

Complementary and Alternative Medicine is helpful in common cardiovascular risk factors including obesity, hypertension, and other co - morbidities that are major public health issues [11]. By application of the water with different temperatures, one can increase or decrease the rate of blood flow through an organ or area of the body and can either increase or decrease the total volume of blood in an organ or area of the body based on the five physiological principles revulsive effect, derivative effect, spinal cord reflex, collateral circulation, and arterial trunk reflex [12]. In another study, they found that short - term exposure to cold water immersion restores the impaired vagal modulation. Water immersion increases the vagal - related HRV indices. It may be due to the stimulation of pressure - dependent baroreceptors, and also due to the co - activation of cold receptors with the cold water immersion [13]. The hydrostatic pressure created by the head - out water immersion condition shifts peripheral blood into the thoracic vasculature, thereby increases central blood volume, stroke volume, cardiac output, and central venous pressure. This helps in the improvement of parasympathetic activity and inhibits sympathetic activity [14]. Application of cold spinal spray on the body enhances the sympathetic activity and has a role in maintaining the cardiac tone and preventing various cardiovascular ailments. Whereas a neutral spinal spray enhances parasympathetic activity and can be applied effectively to treat stress, insomnia and anxiety [15]

Studies showed that BMI has significant effects on all of the lung volumes, and the greatest effects were on FRC and ERV, which occurred at BMI values < 30 kg/m2 [16]Repeated cold stimulations (affusions) can influence the frequency of respiratory infections and improve subjective well - being [17]. Few studies suggested that hydrotherapy in a pool with water at 38 °C for 30 min per day, 6 days per week, for 2 months was useful for improving cardiac function in patients with chronic pulmonary emphysema [18]. A study provides evidence that if practiced regularly, a combined intervention of naturopathy and yoga is an effective alternative treatment for bronchial asthma [19].

Cold spinal bath reduces sympathetic tone and shifts symapthovagal balance towards vagal dominance and hence support the claim that cold spinal bath can be effectively used in lowering the blood pressure in Hypertension [20]. IBA (Ice Bag Application) to head and spine could be considered to be better than TWBA (Tap Water Bag Application) in improving the cardiovascular functions in healthy volunteers [21]. A cool spinal bath for 15 minutes has shown a significant short - term reduction in both systolic and diastolic blood pressure, pulse rate and temperature which indicate that a cool spinal immersion may potentially have a role in managing hypertension [22]. A significant decrease in sympathetic activity and a shift of sympathovagal balance towards vagal dominance immediately after the intervention of cold spinal spray is observed. Therefore CSS can be helpful in the immediate reduction of blood pressure in primary HTN patients [23]

3. Problem Definition

In view of previous studies, innervations of respiratory muscles over spinal nerves and in relation of spinal respiratory motor neurons with lung volumes shows that external application over spinal areas enhance the respiratory functions, spinal spray which indeed helps in stimulating the spinal region might also enhances the respiratory functions. Also body mass index which is increased with increase in fat deposition has the effect over respiratory functions. There are few studies on the superficial effect of cold spinal spray on the body and there is no scientific recording regarding the use of CSS in respiratory system. Thus this study aimed to evaluate the effect of CSS specifically in respiratory functions in healthy individuals and to compare its effect with that of obese individuals.

4. Methodology

A total of 80 subjects are screened and those who fulfill the inclusion criteria and diagnostic criteria, 60 subjects are recruited for the study. They were randomly divided into two groups based on the body mass index where Group 1

(n=30) normal BMI (18.5 to 24.9kg/m^2) Individuals, Group 2 (n=30) obesity of BMI (30 to 40kg/m^2) individuals. Pre assessment was recorded for both the groups before the intervention. On day 1 cold spinal spray intervention was given to Group 1. On the same day cold spinal spray intervention was given to Group 2. Post data was recorded immediately after the intervention. Duration of the study is 1 day Informed consent was obtained from each participant before the study. Ethical clearance is obtained from the institutional ethical committee**.**

Both male and female with Age - 18 to 40 years, Normal BMI (18.5 to 24.9 kg/m2) or Obesity of BMI (30 - 40 kg/m2) were included in the study and individuals with co morbidities, drug abuse and alcohol consumption and individuals on medication were excluded from the study.

Subject is made to be with minimal dress and asked to lie on the spinal spray tub.

A spinal spray tub consists of a fiber perforated tube at the center of the tub, this tube is connected with a pipe to a 0.5 H. P. motor adjusted below the tub which is connected to water supply. The subject is asked to be in minimum dress and made to lie down in the supine position on the tub and start the machine. There will be constant spray from perforated tube ascending to surface of the body directly to the spinal cord region for a span of 20 minutes.

The temperature of the water of cold spinal spray will be measured by a digital thermometer and is maintained between 18°C to 24°C for both the groups. Assessment will be done 5 minutes before and immediately after intervention.

The systolic and diastolic blood pressure is measure manually by sphygmomanometer. The pulse rate is monitored manually by palpating radial artery for 1 minute. The respiratory rate is monitored manually by the number of respiratory movements in 1 minute. The pulmonary functions such Forced Expiratory Volume in one second (FEV1), Forced Vital Capacity (FVC) FEV1/FVC ratio are checked through spirometer with the proper instructions to the subjects.

Kolmogorov - Smirnov tests showed that the data is normally distributed. Analysis of variance was performed to assess the between group differences after adjusting for the baseline values. Paired samples t test was performed to assess the within group differences in lung functions were assessed using Spirometer amongst the obese and non - obese groups before and immediately after the cold spinal spray intervention.

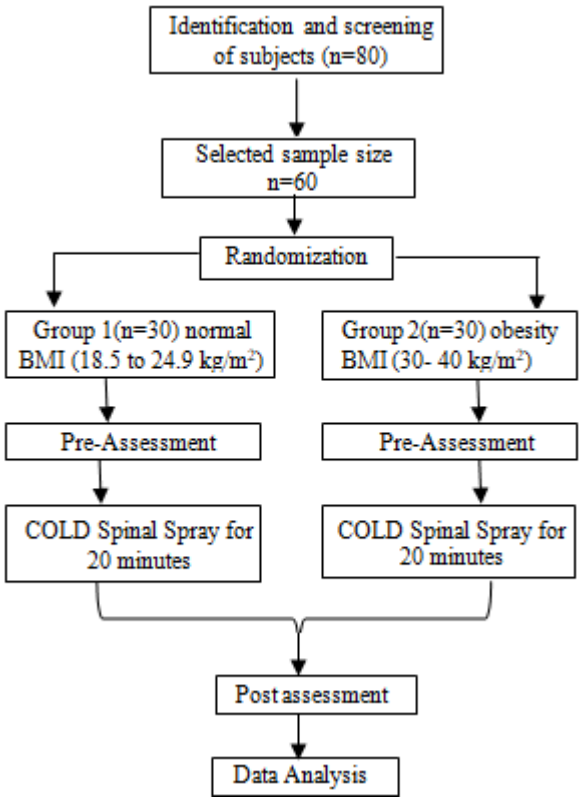

Figure 1: Illustration of Study Plan

5. Results/ Discussion

Sixty subjects of age 24.43±2.52 years were classified into obese and non-obese groups based on their Body mass index. Subjects with BMI 18.5 to 24.9 kg/m^2 and 30 to 39.9 kg/m^2 were recruited in the non-obese and obese groups respectively.15 males and females each were recruited in both the groups.

Analysis of variance for between group changes adjusted for their respective baseline values and post-hoc Bonferroni test for multiple correction demonstrated a significant reduction of respiratory rate, diastolic blood pressure, pulse rate in the non-obese group as compared to the obese group. Also, a significant increase in FVC, FEV1/FVC were observed in non-obese group. (Refer Table 1).
Within group changes demonstrated significant differences in Respiratory rate, Systolic blood pressure, diastolic blood pressure, pulse rate, Forced Expiratory Volume in the 1st second, forced vital capacity and FEV1/FVC ratio in the non obese group.

Paired samples t test for within group changes showed a significant reduction in the pulse rate, systolic blood pressure, diastolic blood pressure and respiratory rate in both the groups that received cold spinal spray in which increased reduction was found in non-obese group

Obesity has a potential to have a direct effect on respiratory well-being, since it consumes more oxygen and produce more carbon dioxide and at the same time it stiffens the respiratory system and increases the mechanical work needed for breathing [24] which demonstrated a significant reduction of respiratory rate, diastolic blood pressure, pulse rate in the non-obese group as compared to the obese. The

reduction in blood pressure is due to the Cold induced vasodilation by stimulation of TRPM8 (Transient Receptor Potential Action Channel Subfamily M Member 8) [25]

The TRPM8 is a thermally regulated protein expressed in sensory neuron which is activated by the cold temperature. They respond to the stimulus from temperature and pressure in the peripheral nervous system and cause the entry of Na+ and Ca2+ ions to the cell leads to a depolarization which inhibits the vasoconstriction activity and a reduction in sympathetic nerve mediated contraction. TRPM8 channels are activated in sensory axon collateral nerves on the local application of cold water which releases the vasodilator substance, from the site of application. That is the contractile action of sympathetic neurotransmitters can be easily antagonized by TRPM8 activation or as the vasoconstrictor inhibition by the TRPM8 agonist. The concurrent blockage of the sympathetic vasoconstriction tone can also be due to its effect on intracellular calcium stores. This shows that the TRPM8 activation by cold stimulus moderately lowers blood pressure and mediates the flow [26]. This flow helps in the increased blood flow to the vital organs and regularise the cardiovascular variables.

Another study cool spinal bath showed a significant effect in immediate reduction of blood pressure and pulse rate in normotensive patients [22]. A significant decrease in sympathetic activity and a shift of sympathovagal balance towards vagal dominance immediately after the intervention of cold spinal spray is observed in another study conducted [23].

There is a significant differences in Respiratory rate, Systolic blood pressure, diastolic blood pressure, pulse rate immediately after cold spinal spray which may be due to cold stimulation which triggers peripheral vasoconstriction, leading to a shift in blood volume. The resulting increase in central pressure in turn activates the baroreflex, responsible for reducing sympathetic nerve activity while shifting autonomic heart rate control towards a parasympathetic dominance and regulates the parasympathetic variables [13]. The other possible mechanism behind the decrease in blood pressure observed in this study may be due to the action and reaction phase succeeding any hydriatic applications. Initially it acts on superficial reflex areas, which can lead to sympathetic arousal in action phase, whereas in the reaction phase there will be an increased pressure on the carotid body facilitated by the sudden gasp after continuous stimulation, eliciting the efferent nerve roots to the nucleus of solitary tract that controls the postganglionic parasympathetic fibres that lowers down the blood pressure [22]
This is also suggestive of parasympathetic dominance and has effect on cardiovascular variables which also includes respiratory rate which slows down the breathing and regularise the respiratory movements comparing prior to the intervention.

Some studies found that lower values of FVC is associated with an increased respiratory rate and decreased FEV1/FVC ratio [27] suggestive of respiratory rate is inversely proportional to the pulmonary functions. The significant reduction in respiratory rate in this study indirectly influence upon the pulmonary functions. Also the increased blood flow due to cold induced vasodilation would have relaxed the respiratory muscle to expire more air comparatively. A study proves that the cold chest pack improves PEFR on bronchial asthma patients [24]. Another study found that the repeated cold stimulations (affusions) can influence the frequency of respiratory infections and improve subjective well-being [17].

Hence, there is significant improvement in the Forced Expiratory Volume in the 1st second [P<0.0005], forced vital capacity [P<0.0005] and FEV1/FVC ratio [P<0.0005] in the non obese group which is demonstrated through within group analysis. Along with all these mechanisms, the continuous stimulations over spine may also have additional effect on lung functions because the respiratory muscles are innervated by spinal nerves [28] and hence cold spinal spray has effect on respiratory functions in healthy individuals comparing to the obese individuals.

Variables	Non Obese Group		Obese Group		F Value	Significance	$p\eta^2$
	Pre (Mean±SD)	Post (Mean±SD)	Pre (Mean±SD)	Post (Mean±SD)			
RR	18.32±2.62	15.6±2.7#	21.3±2.21	19.53±1.8#	14.765	≤0.0005	0.206
SBP	120.8±5.37	115.67±9.44#	126.27±4.52	123.4±3.53#	1.284	0.26	0.022
DBP	81.2±6.42	76.07±4.44#	84±5.22	80.33±4.7#	8.097	0.006	0.124
PR	82.88±4.94	72.4±4.25#	85.33±5.55	79.93±5.0#	61.214	≤0.0005	0.518
FEV1	2.98±0.27	3.13±0.27#	2.46±0.13	2.52±0.1#	17.22	≤0.0005	0.23
FVC	3.84±0.20	4.0±0.2#	3.34±0.12	3.41±0.91#	25.6	≤0.0005	0.310
FEV1/FVC	77.17±3.17	77.95±3.2#	73.57±1.58	73.77±1.59#	7.83	0.007	0.121

Table 1: Table representing Mean±SD values before and immediately after the intervention in the non-obese and obese groups. Analysis of variance was performed for between group analysis and paired samples t test was performed to assess the within group changes.
#: Level of significance p≤0.0005 for within group changes

6. Conclusion

The present study concluded that the immediate effect of cold spinal spray improves respiratory functions in both healthy individuals and obesity individuals and there is significant improvement in healthy individuals comparing to those of obese individuals.

Further study on longer duration and follow up studies to be done to conclude the tonic effects of cold spinal spray on respiratory functions and hence can be trialed on patients with respiratory abnormalities to enhance their condition.

7. Future Scope

The distribution of fat varies in genders and individual and hence respiratory function varies based on the deposition of fat in obese individuals. Hence further study can be done including any one gender. The use of Spirometry primarily reflects large airway flow and depends on the voluntary effort and muscular strength of the patient. This study was conducted on short duration and hence long term study can give more information and strong evidence on the tonic action of the effect produced. In future studies, including other respiratory variables will give the detailed characteristic of respiratory functions when cold spinal spray is given.

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