OPEN ACCESS
Scholars International Journal of Biochemistry
Abbreviated Key Title: Sch Int J Biochem
ISSN 2616-8650 (Print) |ISSN 2617-3476 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Original Research Article

Spirometric Analysis of Vitamin C and Its Effect on Lung Functions of Athletes

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DOI: 10.36348/sijb.2023.v06i05.003 | **Received:** 03.04.2023 | **Accepted:** 16.05.2023 | **Published:** 20.05.2023

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Abstract

Commonly used vitamins such as vitamin C is seen by many athletes as nutritional supplement rather than a performance enhancing drug that boost pulmonary function parameters. This research work is aimed at investigating the effect of vitamin C on Spirometric parameters of athletes. 100 participants were used, 50 for each test group (Vitamin C) and water as control group. Spirometry and peak flow measurements were carried out on each participant. The vitamin C administered orally at a dose of 1.50mg/kg body weight and 35ml of water given orally, the body mass index (BMI), age, sex considered. Measurements were taken before and after one hour of administration of drugs. The results show mean PEFR male and female for Ascorbic Acid test group as 535.2±207.79L/Min and 322.76±20.39L/Min respectively. Control group PEFR male and female as 364.8±23.20L/Min and 325.6±20.45L/Min respectively. Control groups PEFR male and female as 450.6±51.45L/Min and 290±34.90L/Min for Vitamin C, 318±16.26L/Min and 275.20±14.77L/Min for water respectively. Vitamin C increases PEFR much more than water, ERV, IC, VC and IVC were increased by Ascorbic Acid while water decreased ERV, IC, VC, and IVC. The vitamin C effect shows a significant ($p<0.05$) increase in PEFR, indicating a minimal response of smooth muscle to sympathomimetic. The research work supports the performance enhancing role of Vitamin C, more pronounced in males than females. The finding of this study actually shows that vitamin C indeed has beneficial effect on pulmonary function which means enhancement of performance of athletes. The relatively lower values in females in this study correspond with the report that progesterone reduces fatigue and lowers exercise tolerance (Van-Haren *et al*., 1998), the participants have high reserve expiratory abilities. This might be due to the fact that they are athletes, meaning they always engage in active regular bodily exercises.

Keywords: Spirometry, Vitamin C, Pulmonary function, Athletes.

INTRODUCTION

An athlete is a person who competes in one or more sports that involve physical strength, speed, or endurance. Athletes may be professionals or amateurs (Wikipedia). The athletes must be well trained to be able to effectively perform in any competition. These are persons who engage themselves in sporting games for the purpose of exercising their body or for a competition. Sporting activities are highly competitive due to interests as a result of rewards in – terms of finance and fame which has brought riches to athletes. As a lucrative activity, most athletes are tempted to involve in doping (taking of drugs) for the purpose of increasing or enhancing their performances, it's necessary to note that doping has adverse effect apart from enhancing physical performance.There are certain Physiological factors that determine the athlete's performance and some of these physiological factors anthropometric measures and pulmonary function parameters among others.

Sporting activities are highly competitive due to interests as a result of rewards in – terms of finance and fame which has brought riches to athletes. As a lucrative activity, most athletes are tempted to involve in doping (taking of drugs) for the purpose of increasing or enhancing their performances, it's necessary to note that doping has adverse effect apart from enhancing

physical performance and substances varies from food supplement to drugs, vitamins. Vitamin C also known as Ascorbic Acid, is found in foods such as Citrus juices and fruits, tomatoes, barriers, potatoes with skins, green and red peppers, broccoli and spinach. It's recommended that adults consume at least 60miligrams of Vitamin C each day which is about the in an orange (Mckeever TM, Serivener *et al*., 2002).

In our environment, vitamin C are frequently used clinically, and even on self-medication. Commonly used vitamins such as vitamin C is seen by many athletes as nutritional supplement rather than a performance enhancing drug that boost pulmonary function parameters. Weber *et al*., (1996) reported that ascorbic acid protects against pulmonary dysfunction. Ascorbic acid is an antioxidant (Grievink *et al*., 1998). Vitamin C increases peak expiratory flow rate much more than salbutamol, tidal volume, expiratory reserve volume, Inspiratory reserve volume, Inspiratory capacity, vital capacity are also increased by ascorbic acid while Salbutamol decreases these pulmonary parameters(S.O. Odeh, I.E. Agaba *et al*., 2004). Again, they carried out a systematic review of the effect of Vitamin C supplementation on the common cold, Vitamin C consistently reduced the duration of common cold symptoms, but the effect on common cold incidence was significantly heterogeneous. In their trial with marathon runners, Peter *et al*., (2008) recorded the "Self – reported symptoms including a running nose, sneezing, sore throat, cough and fever" during a 2 – week post –race period. The incidence of post – race cough was significantly reduced in the Vitamin C group compared with the placebo group: in contrast, Vitamin C had no significant effect on the incidence of running nose. Peters did not carry out Virologic or pulmonary function tests before or after the race, and thus the cause of the symptoms in uncertain, few studies have directly measured the effect of Vitamin C supplementation on bronchial responsiveness.

J. Schwartz and ST Weiss (1994) assessed the relationship between dietary Vitamin C intake and level of pulmonary function (forced expiratory volume in Is, FEV1) in 2526 adults seen as part of the National Health and Nutrition Examination Survey (NHANESI) between 1971 and 1974. It has been hypothesized that Vitamin C intake has a protective effect on pulmonary (American Journal of Respiratory and Care Medicine (2002). Anderson and Kippelen reviewed mechanisms and therapeutic approaches to Exercise – induced broncho – constriction (EIB) in athletes; they also found that Vitamin C can also affect Exercise – induced broncho – constriction (EIB). After taking into consideration factors that could affect lung function (such as smoking status), the researchers discovered that people who had better lung function scores after nine years also heed higher Vitamin C intakes. They theorized that consumption of Vitamin C and foods rich in Vitamin C could protect against lung disease. Researchers from the United Kingdom (UK) recently discovered that consuming plenty of Vitamin C might fuel better lung function.

Ogilvy *et al*., (1999) reported that Vitamin C reduced the duration and intensity of broncho – constriction induced by methacholine. Tecklenburg *et al*., (2000) also reported that Vitamin C decreased the levels of pro-inflammatory eicosanoids in urine. These 3 laboratory studies do not, however, define the clinical importance of Vitamin C for athletes. On the other hand, the 6 trials with participants under heavy acute physical stress, indicate that Vitamin C has clinically important effects on the respiratory symptoms of some athletes, although it is not clear to what degree that effect is directed at their viral infections and the physical injury to their airways (Harri Hemila, 2008). This means that more trials that examine the mechanisms and therapeutic effects of Vitamin C on the symptoms of athletes are warranted. The effects of ascorbic acid on pulmonary function have been investigated (Hu *et al*., 1998, Ibadan and Osubor, 1999).

Following the fast – growing developmental advancement in all spheres of life in our society today there is the need to carry out this research to put to test the hypothesis that Ascorbic Acid (vitamin C) intake has a protective effect on pulmonary function with intension of investigating it effect on lung function of athletes and in comparison of their pulmonary performance in – order to ascertain earlier calms on the outcome of their findings on aspect in this part of our society so that Rivers state sports teams will orient their athletes of the health implication of the said drugs and discourage them to indulge in the practice of doping for the sake of enhancing performance during competitions. It is imperative therefore to carryout researches to investigate the various effects of the use of drugs in order to maintain sanity in sports and creates an enabling environment for individuals with natural ability to compete or partake in competitions and deter the notion of no drugs, no better performance.

Materials

- 100 human Participants
- Spirometer, spirolab II AII MIR S/N A23 – 050.3550
- Personal Best Full Range Peak Flow Meter
- Nose Clip
- Methylated Spirit cotton wool
- Measuring Tape
- Weighing balance (Hana power bathroom scale, pese-personne, BR911)
- A Structured Questionnaire/ Data Collection Sheet
- Recording Pen

Method

The study was carried out on athletes residing within Port-Harcourt who gave their informed consent after explaining the rationale behind the research work. The subjects were interviewed and physically examined with the use of relevant information (which included age, etc.) gotten from fill-up of the questionnaires. Those with respiratory and or cardiovascular disorders were excluded in the whole study. However, hundred (100) human participants made up of twenty-five (25) males and females each vitamin C as test group and water as control group.

Measurement of peak flow meter

Measurement of peak expiratory flow rate was done using a personal best® full range peak flow meter. The subjects took a deep breath, applied his/her lip firmly to the mouth piece, expires as hard as fast as possible. A direct reading of the peak expiratory flow was obtained before and after drugs administration on the peak flow meter.

Spirometric measurement

The pulmonary function tests were carried out using spirolab II A\\ MIR peak meter after their age, weight, height were recorded and also, before and after one hour of the administration of the ascorbic acid orally . The test module was then activated and the subjects were properly instructed about the procedure to be performed. All pulmonary tests were done on subjects, comfortably seated in an upright position. The participants were connected to the mouth piece and were asked to breath in order to familiarize with the equipment. During the test the participants were adequately encouraged to perform at their optimum level and also a nose clip was applied during the entire process. The parameters analyzed from the equipment were expiratory reserved volume (ERV), Inspiratory vital capacity (IVC), Inspiratory capacity (IC), vital capacity (VC).The algorithms used for the calculation have been validated for populations of African descent with the new software added up to the machine.

2.2.3 Anthropometrical measurement

The weights, heights of the subjects were taken using measuring tape, weighing scale while age and sexes were recorded, BMI was calculated as weight (kg) divided by the square of the height in meters (m) kg/m2.

2.2.4 Drug administration

The Vitamin C was given orally at a dose of 1.5 mg/kg body weight, and Water at dose of 35ml/kg body weight orally also measurements were taken after one hour of the administration of the drugs.

Data analysis

The outcome of pulmonary function test was presented as a mean and standard deviation for each parameter. Chi-square was used to compare groups' results and values of less than 0.05 were considered as significant while confidence level was taken to be 95%.

RESULT ANALYSIS

Subject characteristics

The mean age of male participants for vitamin C was 27.68±1.14 years and 23.80±0.81 years for female, mean heights were 164±3.30.cm and 157.9±3.21cm for male and female while mean weights for were 68.84±1.57kg and 64.96±1.43 kg for male and female respectively. The mean age of male subjects for salbutamol were 26.76±1.35 years and 27.04±1.28 years for female, mean heights were 167.6±1.54cm and 162.52±1.56cm for male and female while mean weights for were 65.44±1.83 kg and 69.20±2.90 kg for male and female respectively. while mean BMI for were 26.52±1.79Kg/m2 and 27.24±1.85 kg for male and female for ascorbic acid (group 1) and 26.40±1.01 kg/m2, 22.82±0.69 kg/m2 for control group 2 for male and female respectively.

Table 1a & 1b below show Anthropometric Parameters

Table 1a:

	Test Group			
Parameter	Male(mean)	St.Dev	Female	St.Dev
Age	27.68±1.14	5.69	23.80±0.81	4.07
HT	164±3.30	16.49	157.9±3.21	16.06
WT	68.84±1.57	7.86	64.96±1.43	7.14
BMI	26.52±1.79	8.45	27.24±1.85	9.25

Table 1b:

	Control Group			
Parameter	Male(mean)	St. Dev	Female	St.Dev
AGE	26.76±1.35	1.80	27.04±1.28	6.41
HT	167.6±1.54	7.72	162.52.±1.56	7.78
WT	65.44±1.83	9.14	69,20±2.90	14.51
BMI	26.40±1.01	3.47	22.82±0.69	3.47

Peak flow measurements

The mean peak flow rate of male and female subjects for ascorbic acid (group1) were 535.2±207.79 L/Min and 322.76±20.39 L/Min respectively. The PEFR in male was significantly higher than female and in both male and female control (before admin.of drug) group ($p > 0.05$). PEFR for control group were 364.8±23.20 L/Min and 325.6±20.45 L/Min for male and female respectively. The male control group was significantly higher than female salbutamol and also higher in the female control (before admin.of drug) group ($p>0.05$). The PEFR male and female for control(before admin.of vitamin C) group were 450.6±51.45 L/Min and 290±34.90 L/Min for group1 male and female respectively while 318±16.26L/Min and 275.20±14.77L/Min for male and female respectively. The male was significantly higher than the female in the control group.

Table 2: Mean Peak Expiratory Flow Rate (L/Min) After One Hour Of Vitamin Administration

Test group				**Control group**			
Male(mean)	St. Dev	Female		Male(mean)	St. Dev	Female	
535.2±207.79	103.93	322.76±20.39	101.93	364.8±23.20	116	325.6±20.45	102.23

Table 3: Mean Peak Expiratory Flow Rate (L/MIN) Before Vitamin Administration

Test group				**Control group**			
Male(Mean)	St.Dev	Female		Male(Mean)	St.dev	Female	
450.6±51.45	97.20	290±34.90	92.70	318.±16.26	81.29	275.20±14.77	73.83

The expiratory reserve volume (ERV) for vitamin C (group1) were 1.36±0.48L, and 1.29±0.68L male and female respectively and 1.30±0.21L and 1.25±0.59L water (group2) for male and female respectively, there are significant changes in the female group as well as the male between group1 and group2 for both male, female($p>0.05$). The inspiratory capacity(IC) has a significant difference in the male and groups on ascorbic acid, water significantly lower in all the group than control group(before admin. of vitamin C) in the female ($p<0.05$). Vital capacity(VC) were 3.32±0.34L and 3.19±0.38L for male and female vitamin group respectively, significantly higher than in male and female control group, were 2.87±0.19L and 2.55±0.23L respectively. The inspiratory vital capacity (IVC) also showed any significant difference from the control for any of the study groups.

The results for the spirometry after one hour of administration of vitamin C are shown in the Table 4a & 4b.

Table 4a:

	Test Group			
	Male(mean)	St. Dev	Female	
ERV	1.36±0.48	0.24	1.29±0.68	0.34
IC	2.56±0.26	1.28	3.04±0.54	2.71
VC	3.32±0.34	1.72	3.19±0.38	1.89
IVC	3.67±0.14	0.71	3.16±0.24	1.18

The results for the spirometry after one hour of administration of vitamin are shown in the 4b below.

Table 4b:

	Control Group			
Parameter	Male(mean)	St. Dev	Female	
ERV	1.30±0.21	0.14	1.25±0.59	0.29
IC	2.46±0.12	0.58	2.12±0.13	0.64
VC	2.87±0.19	0.99	2.55±0.23	1.15
IVC	3.56±0.14	0.68	3.12±0.18	0.91

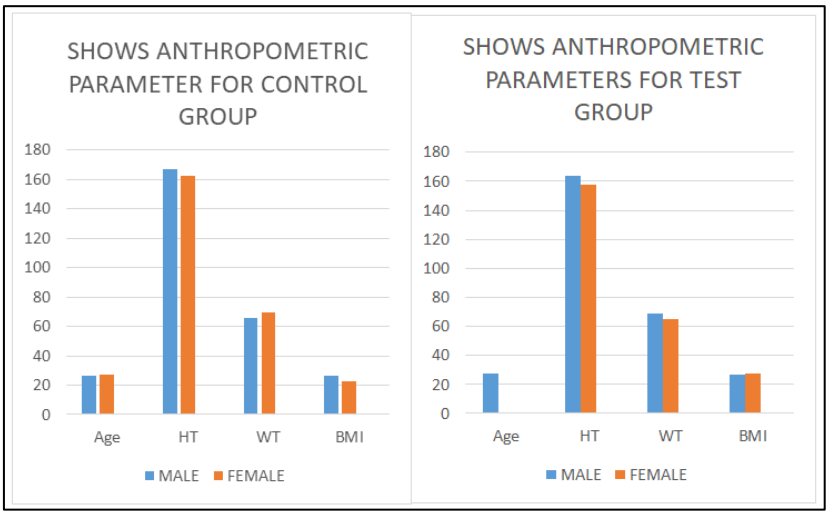
Table 5: The results for the spirometry before of administration of vitamin C

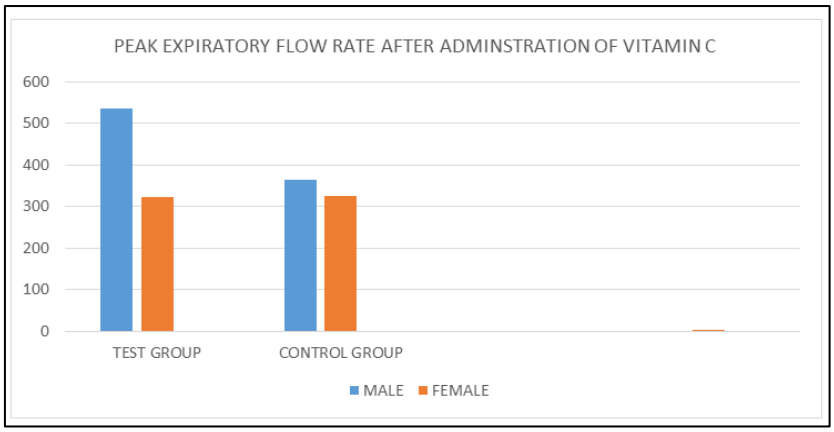
	Test Group			
Parameter	Male(mean)	St. Dev	Female	
ERV	1.35±0.07	0.34	1.05±0.66	0.33
IC	2.64±0.23	1.17	2.27±0.11	0.56
VC	2.46±0.41	2.04	2.65±0.34	1.72
IVC	3.55±0.17	0.84	3.02±0.17	0.83

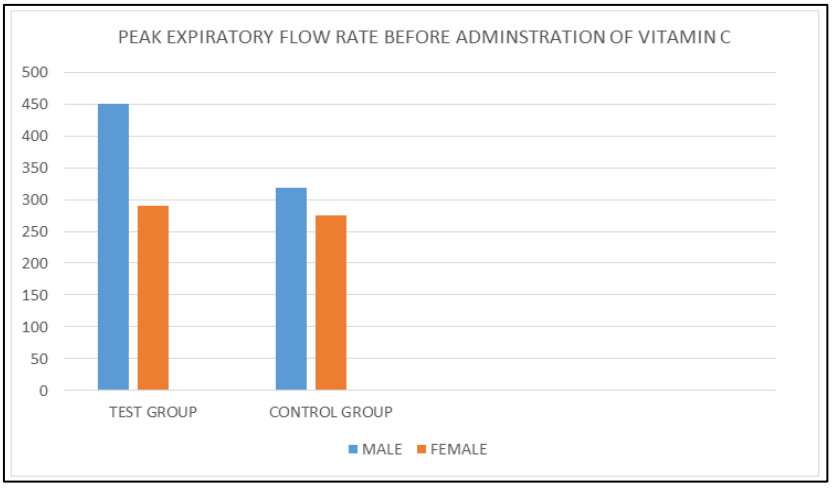
Table 6: The results for the spirometry before of administration of vitamin C

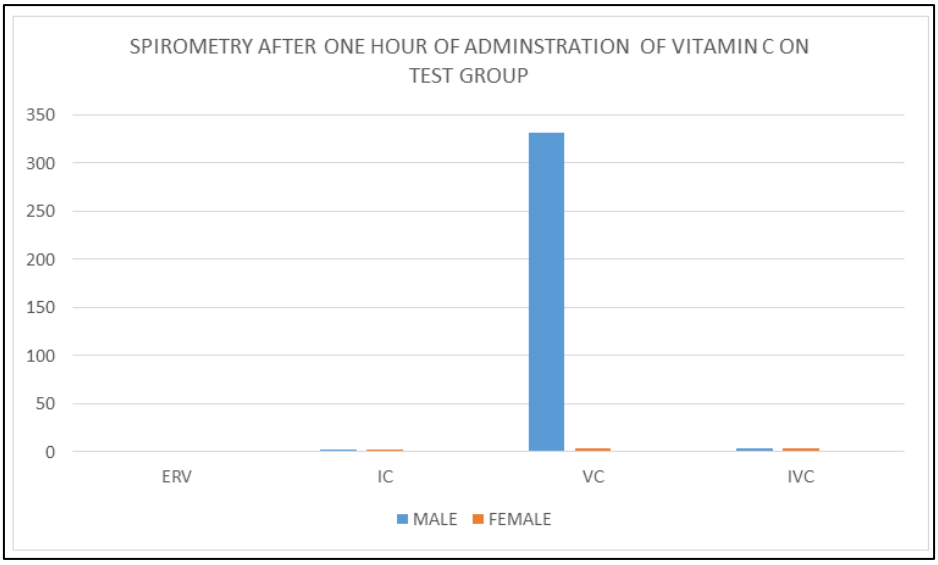
	Control Group			
Parameter	Male(mean)	St. Dev	Female	
ERV	1.50±0.22	0.12	1.20±0.56	0.26
IC	2.61±0.24	0.34	2.01±0.10	0.35
VC	2.91±0.20	1.19	2.23±0.24	1.17
IVC	3.99±0.15	0.81	3.02±0.14	0.72

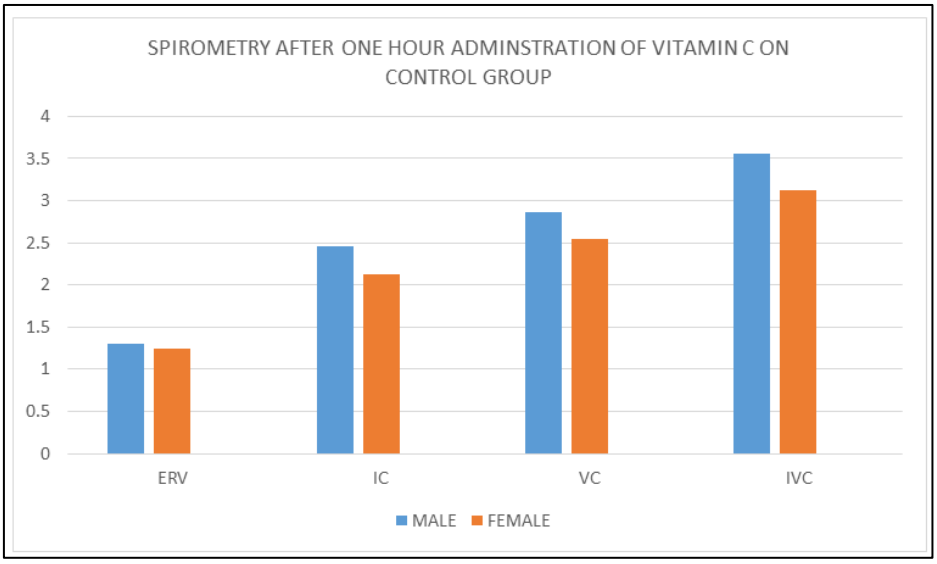
GRAPHICAL REPRESENTATIONS

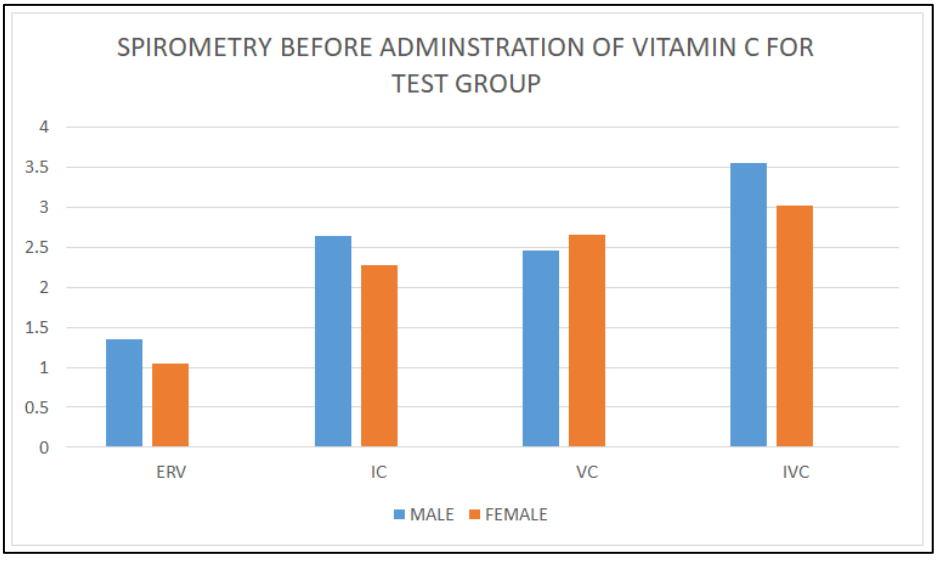


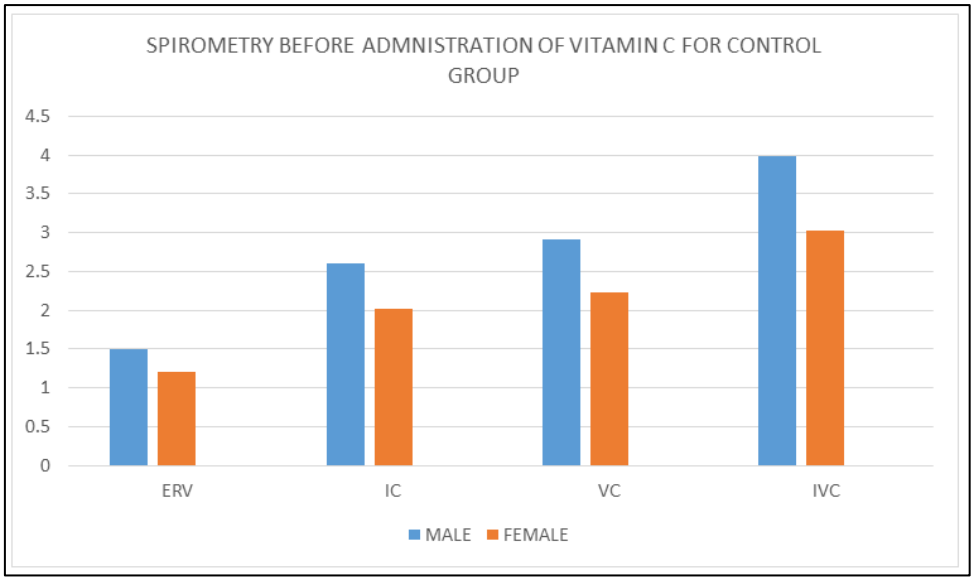












DISCUSSION

Commonly used vitamins such as vitamin C is seen by many athletes as nutritional supplement rather than a performance enhancing drug that boost pulmonary function parameters. This study has the male Peak Expiratory Flow Rate (PEFR) values are higher than female which were expected, 535.2±207.79 L/Min and 322.76±20.39 L/Min for male and female respectively for ascorbic acid (vitamin C), higher than any other group. The standard value for peak expiratory flow rate (PEFR) is between 510 and 560 L/Min (Slonim and Hamilton, 1987). In study, PEFR value of 364.8 ±23.20L/Min is lower than this range. Ascorbic Acid enhanced the PEFR value to 535.2L/Min. This does not corroborate the study of Ibadin and Osubor (1999) which reported a lack of effect of vitamin C on pulmonary function. Vitamin C protect against loss of pulmonary function (Hu *et al*., 1998) Grievmik *et al*., (1998) also supported the beneficial role of vitamin C in respiration dysfunction. The vitamin C effect shows a significant ($p<0.05$) increase in PEFR, indicating a minimal response of smooth muscle to sympathomimetics. Lands *et al*., (1979) posited that the effect of B-adrenoceptor agonists actually become important in obstructive pulmonary disorders. The report of person (1979) that the effect of b-agonists is more pronounced in healthy lungs compared to diseased lungs is not corroborated by the present study. Expiratory reserve volume (ERV) is higher for all the groups than standard values of 1.0L to 1.2L .Ascorbic Acid (vitamin C) increased ERV in both male and female (1.36±0.48 Land 1.29±0.68 L) respectively, there is a significant change compared with the standard values ($p<0.05$). Control group are 1.30±0.21 L and 1.25±0.59L for both sexes respectively. ERV reflects the thoracic and abdominal muscles strength, thoracic mobility and balance of elastic forces affecting spontaneous expiration (Gelb and Zamel, 2001). From the study, the participants have high reserve expiratory abilities. This might be due to the fact that they are athletes, meaning they always engage in active regular bodily exercises. Inspiratory vital capacity (IVC) is higher than the ERV and IC and VC values in all the groups for male and female. showed an increased VC (2.46±0.41 L) for male in control group and deceased in control group, Ascorbic Acid also has high value of VC (3.32±0.34 L) for male which is significant ($p<0.05$). VC is usually reduced in severe respiratory muscle weakness (Syabbalo, 1998). Ascorbic Acid increases inspiratory Vital capacity (IVC) significantly in both sexes, all other group in study are lower than the ascorbic acid group for male and female respectively. IVC describes a balance between lung and chest elasticity, muscle strength and thorax mobility. Discrepancies in inspiratory vital capacity (IVC) and expiratory reserve volume (ERV) may be explained by lack of parenchymal airway narrowing (Stanescu *et al*., 2000). The Inspiratory capacity (IC) more frequently used. At low volumes, it is expected that the vasculature would strain and stiffen (Topulos *et al*., 2000; Schulz *et al*., 1999). This study shows Inspiratory capacity (IC) rising with vitamin C. The mechanism is unknown yet. It however corresponds with hypothesis that Ascorbic Acid (vitamin C) protects against the loss of pulmonary function. Hu *et al*., (1998) have indeed reported an adverse relationship between Ascorbic Acid (vitamin C) and cough. The relatively lower values in females in the this study correspond with the report that progesterone reduces fatigue and lowers exercise tolerance (Van-Haren *et al*., 1998).

CONCLUSION

The finding of this study actually shows that vitamin C indeed has beneficial effect on pulmonary function which means enhancement of performance of athletes. The relatively lower values in females in the this study correspond with the report that progesterone reduces fatigue and lowers exercise tolerance (Van-Haren *et al*., 1998). The vitamin C effect shows a significant ($p<0.05$) increase in PEFR, indicating a

minimal response of smooth muscle to sympathomimetics. It however corresponds with hypothesis that Ascorbic Acid (vitamin C) protects against the loss of pulmonary function. From the study, the participants have high reserve expiratory abilities. This might be due to the fact that they are athletes, meaning they always engage in active regular bodily exercises.

RECOMMENDATION

1. It is advisable for people especially athletes to ensure adequate usage vitamin C as supplements in diets or drug. Therefore, they are encouraged to feed well of fruits which is generally believed to be a good sources of vitamin C.
2. Athletes should avoid doping prior to competition for the sake of improving the physical performance. Apart from being unlawful act punishable under international sporting body, doping has negative medical implications to the practitioner.

REFERENCES

- Aderele, W. I., & Oduwole, O. (1983). Peak expository flow rate in healthy school children. *Nig J Paed*, 10, 45-55.
- Aggarwal, A. N., Gupta, D., Behera, D., & Jindal, S. K. (2000). Analysis of static pulmonary mechanics helps to identify functional defects in survivors of acute respiratory distress syndrome. *Critical care medicine*, *28*(10), 3480-3483.
- Andresson, R. G. G., Johansson, S. R. M. (1979). B – adrenoceptors and the CAMP System. *Acta Pharmalogica of Toxicologica*, 499(1).
- Becker, M. D., Berkmen, Y. M., Austin, J. H., Mun, I. K., Romney, B. M., Rozenshtein, A., ... & Ginsburg, M. E. (1998). Lung volumes before and after lung volume reduction surgery: quantitative CT analysis. *American journal of respiratory and critical care medicine*, *157*(5), 1593-1599.
- Cassino, C., Berger, K. I., Goldring, R. M., Norman, R. G., Kammerman, S., Ciotoli, C., & Reibman, J. (2000). Duration of asthma and physiologic outcomes in elderly nonsmokers. *American journal of respiratory and critical care medicine*, *162*(4), 1423-1428.
- Collomp, K., Candau, R., Lasne, F., Labsy, Z., Prefaut, C., & De Ceaurriz, J. (2000). Effects of short-term oral salbutamol administration on exercise endurance and metabolism. *Journal of Applied Physiology*, *89*(2), 430-436.
- Corzo–Alvarez, G. R. (1998). Lung Volumes in non – smoking healthy in Maracaibo, Venezuela. *Investigation Clinic*, 39(1), 3-17.
- David, S., & Jackie, B. (1998). Hole's Essentials of Human Anatomy and Physiology, Sixth (6^{th}) Edition; published in the USA.
- Eisen, E. A., Wegman, D. H., Louis, T. A., Smith, T. J., & Peters, J. M. (1995). Healthy worker effect in a longitudinal study of one-second forced expiratory volume (FEV1) and chronic exposure to granite dust. *International journal of epidemiology*, *24*(6), 1154-1162.
- Fujita, M., Shannon, J. M., Irvin, C. G., Fagan, K. A., Cool, C., Augustin, A., & Mason, R. J. (2001). Overexpression of tumor necrosis factor-α produces an increase in lung volumes and pulmonary hypertension. *American Journal of Physiology-Lung Cellular and Molecular Physiology*, *280*(1), L39-L49.
- Galal, M. W., Habib, R. H., Jaeger, D. D., & Lister, G. (1998). Effects of rate and amplitude of breathing on respiratory system elastance and resistance during growth of healthy children. *Pediatric pulmonology*, *25*(4), 270-277.
- Gelb, A. F., & Zamel, N. (2000). Unsuspected pseudophysiologic emphysema in chronic persistent asthma. *American journal of respiratory and critical care medicine*, *162*(5), 1778-1782.
- Grievink, L., Smit, H. A., Ocké, M. C., van't Veer, P., & Kromhout, D. (1998). Dietary intake of antioxidant (pro)-vitamins, respiratory symptoms and pulmonary function: the MORGEN study. *Thorax*, *53*(3), 166-171.
- Grimm, D. R., Chandy, D., Almenott, P. L., Schilero, G., & Lesser. (2000). Airway function: the tetraplegia is associated with reduced based line airway caliber. *Chest*, 118(5), 1397-1404.
- Guyton and Hall. (2000). Textbook of Medical Physiology, 10^{th} edition, published in the USA.
- Hemilä, H. (2009). Vitamin C and exercise-induced bronchoconstriction in athletes. *Journal of Allergy and Clinical Immunology*, *123*(1), 274-275.
- Hu, G., Zhang, X., Chen, J., Peto, R., Campbell, T. C., & Cassano, P. A. (1998). Dietary vitamin C intake and lung function in rural China. *American journal of epidemiology*, *148*(6), 594-599.
- Ibadin M. O., & Osubor, C. C. (1999). Plasma Ascorbic acid status in Nigerian children with bacterial upper respiratory tract infection. *Nigerian Medical Practitioner*, 37(1,2), 18-20.
- Ingenito, E. P., Evans, R. B., Loring, S. H., Kaczka, D. W., Rodenhouse, J. D., Body, S. C., ... & Reilly Jr, J. J. (1998). Relation between preoperative inspiratory lung resistance and the outcome of lung-volume–reduction surgery for emphysema. *New England Journal of Medicine*, *338*(17), 1181-1185.
- Jaja, S. I., & Fagbenro, A. O. (1995). Peak expiratory flow rate in Nigerian school children. *African journal of medicine and medical sciences*, *24*(4), 379-384.
- Johnson, Z. M., & Erasmus, L. D. (1968). Clinical spirometry in normal Bantu children. *Am Review of Resp Dis*, 97, 585-590.

- Lands, A., Arnold, A., McAuliff, J. P., Luduena, F. P., & BROWN, J. T. (1967). Differentiation of receptor systems activated by sympathomimetic amines. *Nature*, *214*, 597-598.
- McKeever, T. M., Scrivener, S., Broadfield, E., Jones, Z., Britton, J., & Lewis, S. A. (2002). Prospective study of diet and decline in lung function in a general population. *American journal of respiratory and critical care medicine*, *165*(9), 1299-1303.
- Meyer, F. J., Zugck, C., Haass, M., Otterspoor, L., Strasser, R. H., Kübler, W., & Borst, M. M. (2000). Inefficient ventilation and reduced respiratory muscle capacity in congestive heart failure. *Basic research in cardiology*, *95*, 333-342.
- Monso, E., Fiz, J. M., Izquierdo, J., Alonso, J., Coll, R., Rosell, A., & Morera, J. (1998). Quality of life in severe chronic obstructive pulmonary disease: correlation with lung and muscle function. *Respiratory medicine*, *92*(2), 221-227.
- Odeh, S. O., Agaba, I. E., Sabo, A. M., & Odanaogun, R. A. (2004). Pulmonary Performance In Asymptomatic Young Nigerian Population Following The Administration Of Ascorbic Acid And Salbutamol. *Nigerian Journal of Physiological Sciences*, *19*(1), 48-52.
- Osim, E. E., & Esin, R. A. (1996). Lung function studies in some Nigerian bank workers. *The Central African Journal of Medicine*, *42*(2), 43-46.
- Person, C. G. A. (1979). B – Receptor agonist and permeability in the Lung. *Acta Pharmacological et Toxicologica*, 44(11), 33-35.
- Pillet, O., Manier, G., & Castaing, Y. (1998). Anticholinergic versus beta 2-agonist on gas exchange in COPD: a comparative study in 15 patients. *Monaldi Archives for Chest Disease= Archivio Monaldi per le Malattie del Torace*, *53*(1), 3-8.
- Schwartz, J., & Weiss, S. T. (1994). Original research communications; Relationship between dietary vitamin C intake and pulmonary function in the first National Health and Nutrition Examination Survey (NHANESI), *American Journal of clinical butrition*, 59, 110-114.
- Schylz, H., Eder, G., Heillmann, P., Karg, E., Meyer, T., Schulz, A., Ziesenis, A., & Hayder, J. (1999). Health effects of Sulphur – related environmental air population iv; respiratory Lung function. *Inhalation and Toxicology*, 11(5), 423-438.
- Slonim, N. B., & Hamilton L. H. (1987). Respiratory Physiology, 5th ed. The CV Mosby Company, Toronto pp 48-52.
- Stanescu, D., Veriter C., & Van–de Woesstijine, K. P. (2000). Maximal Inspiratory flow rates in patients with COPD. *Chest*, 118(4), 976-980.
- Stedman's Medical dictionary. (2000). 27th Edition, 351 West Camden Street, Baltimore, Maryland 21201 – 2436 USA.
- Syabbalo, N. (1998). Assessment of Respiratory Muscle Functions and Strength. *Postgraduate Medical Journal*, 74(870), 208-215.
- Topulos, G. P., Brown, R. E., & Butler, J. P. (2000). Influence of lung volume on pulmonary microvascular pressure-volume characteristics. *Journal of Applied Physiology*, *89*(4), 1591-1600.
- Urom, S. E., Antai, A. B., & Osim, E. E. (2004). Symptoms and lung function values in Nigerian men and women exposed to dust generated from crushing of granite rocks in Calabar, Nigeria. *Nigerian Journal of Physiological Sciences*, *19*(1), 41-47.
- Van-Haren, E. H., Davies, I. E., Mol, M. J., & Kondijs, J. W. (1998)… Asthma en zwangerschap. *Ned J Tijdschr Geneeskd*, 142(11), 526-566.
- Walamies, M. A. (1998). Diagnostic role of residual volume in paediatric patients with chronic symptoms of the lower airways. *Clinical Physiology (Oxford, England)*, *18*(1), 49-54.
- Weber, C., Erl, W., Weber, K., & Weber, P. C. (1996). Increased adhesiveness of isolated monocytes to endothelium is prevented by vitamin C intake in smokers. *Circulation*, *93*(8), 1488-1492.
- West, J. B. (1990). Ed: Best and Taylor's Physiological Basis of Medical Practice, 11th ed. Williams and Williams. London. Pp 54-550.
- West, J. B. (1979), Respiratory Physiology, The Essentials. Williams and Willkin. Baltimore. pp 206-221.
- World Health Organization. (1998). Life in the 21st Century: A vision for all. World Health Organization Report. Geneva; pp 90–95.
- Yap, J. C., Moore, D. M., Cleland, J. G., & Pride, N. B. (2000). Effect of supine posture on respiratory mechanics in chronic left ventricular failure. *American journal of respiratory and critical care medicine*, *162*(4), 1285-1291.
- Yernault, J. C., Pride, N., & Laszlo, G. (2000). How the measurement of residual volume developed after Davy (1800). *European Respiratory Journal*, 16(3), 561-564.