Original article

Impact of the vertical sleeve gastrectomy on oxygen consumption kinetics among women post bariatric surgery

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Summary

Introduction: Obesity is considered one of the main health problems of modern society, there are several treatments to reverse it, being bariatric surgery (BS) the most effective method in cases of severe obesity. Cardiorespiratory fitness (CRF) is an aspect of physical condition assessed through maximum oxygen consumption (VO_{2max}); the kinetics of VO_2 is a less studied aspect of CRF; it has been described that this variable allows estimation of the CRF without high physical efforts in comparison with other forms of evaluation; In spite of the above, there is no information regarding the impact that sleeve gastrectomy (SG) has on the CRF evaluated through this variable.
Objective: To determine the impact of SG on the VO_2 kinetics of women with obesity.
Material and method: Quasi-experimental study, 15 women with an age of 32,9 ± 10,3 years and an initial BMI of 35,2 ± 3,9 kg/m^2 participated. The sample is non-probabilistic through a group of volunteers evaluated at three times: before surgery (*pre*), 30 and 90 days post vertical gastrectomy (30*post* and 90*post* respectively). Body weight, body mass index (BMI), waist circumference (WC), VO_{2peak} and VO_2 kinetics were evaluated.
Results: After surgery, the variables body weight, CC and BMI reported a significant decrease (p <0,001) compared to the pre-surgery moment. The relative VO_{2peak} (ml/kg/min) increases between 30*post* and 90*post* (p <0,001); the absolute VO_{2peak} (L/min) decreased between the pre moments with 30*post* and *pre* with 90*post* (p <0,05); the kinetics of VO_2 showed an increase in time at 30*post* (p <0,05).
Conclusion: The VO_2 kinetics is increased in obese women undergoing SG at 30*post* surgery, which shows a deterioration of this capacity.

Key words:
Obesity. Oxygen consumption. Bariatric surgery.

Impacto de la gastrectomía vertical sobre la cinética de consumo de oxígeno en mujeres post cirugía bariátrica

Resumen

Introducción: La obesidad es considerada uno de los principales problemas de salud de la sociedad moderna, existiendo variados tratamientos para revertirla, siendo la cirugía bariátrica (CB) el método más efectivo en los casos de obesidad severa. La capacidad cardiorrespiratoria (CCR) es un componente de la condición física valorada a través del consumo máximo de oxígeno (VO_{2max}); la cinética del VO_2 es un aspecto poco estudiado de la CCR; se ha descrito que esta variable permite estimar la CCR sin elevados esfuerzos físicos en comparación con otras formas de evaluación; a pesar de lo anterior, no existe información respecto del impacto que tiene la gastrectomía vertical (GV) sobre la CCR evaluada a través de esta variable.
Objetivo: Determinar el impacto de la GV en la cinética del VO_2 de mujeres con obesidad.
Material y método: Estudio de tipo cuasi experimental, participaron 15 mujeres con edad de 32,9±10,3 años y un IMC inicial de 35,2±3,9 kg/m^2. La muestra es de tipo no probabilística a través de grupo de voluntarios evaluados en tres momentos: previo a la cirugía *(pre)*, 30 y 90 días post gastrectomía vertical (30*post* y 90*post* respectivamente). Se evaluó peso corporal, índice de masa corporal (IMC), circunferencia cintura (CC), VO_{2peak} y cinética del VO_2.
Resultados: Post cirugía las variables peso corporal, CC e IMC reportan disminución significativa (p<0,001) respecto del momento pre cirugía. El VO_{2peak} relativo (ml/kg/min) aumentó entre 30*post* y 90*post* (p<0,001); el VO_{2peak} absoluto (L/min) disminuyó entre los momentos pre con 30*post* y *pre* con *90post* (p<0,05); la cinética del VO_2 presentó un incremento del tiempo a los 30*post* (p<0,05).
Conclusión: La cinética del VO_2 se ve incrementada en mujeres obesas intervenidas con GV a los 30 días post cirugía, lo que evidencia un deterioro de la capacidad cardiorrespiratoria.

Palabras clave:
Obesidad. Consumo de oxígeno. Cirugía bariátrica.

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Introduction

According to the World Health Organisation (WHO), obesity is defined as the abnormal or excessive accumulation of fat that can deteriorate health, and is considered to be one of the main problems faced by modern society[1]. In Chile, according to the National Health Survey (NHS) 2016-2017, the prevalence of obesity was 31.2% (28.6% among men and 33.7% among women), the main cause considered to be lifestyle in terms of unhealthy eating habits, a lack of physical activity and sedentary behaviour, in addition to genetic, physiological, psychological, social, economic and educational factors[2]. Treatments to combat obesity currently focus on reversing poor eating habits, increasing levels of physical activity, providing psychological support and administering pharmaceutical drugs[3]. In severe cases of obesity, or when the previously mentioned interventions have not had the desired effect, treatment moves on to Bariatric Surgery (BS)[4], considered the most effective treatment in reducing weight in the long term, and proving highly effective for weight loss, leading to a considerable reduction in the associated co-morbilities[4]. Vertical Sleeve Gastrectomy (VSG) is the most used BS in the world, comprising 45.9%[5] of all surgeries of this kind, and in Chile, it constitutes 70.8% of all BS[6].

Physical condition is a combination of physical attributes related to the capacity to perform a task, and may or may not be related to health[7]. Cardio-Respiratory Capacity (CRC) is a component of this condition, used as a health and life-expectancy indicator, demonstrated through maximum oxygen consumption (VO_{2max})[8]. Assessing this variable requires the maximum CRC of the subject, a situation that may be high risk in some cases9. In obese patients, the assessment of this variable is generally sub-maximum, and the term VO_{2peak} is used to denominate the amount of oxygen consumed at the moment the test is stopped, expressed in absolute values (L/min) or values related to body weight (ml/kg/min).

One of the aspects that is rarely addressed regarding VO_2, is its kinetic at the start of the constant load exercise, represented by the tau measurement (τ), which consists in the time response of the VO_2, quantifying stabilisation after a constant load exercise lasting 6-10 minutes, representing the overall function of cardiovascular, pulmonary and muscular-skeletal system activity$_{10}$. Three phases can be discerned for the reaction of the increase of VO_2 in these conditions[11], with the τ value corresponding to the time in seconds in which 63% of the maximum VO_2 plateau is obtained with sub-maximum load in phase II, which has been proven to be sensitive to changes in CRC in subjects with cardio-respiratory pathologies12 and type II diabetes *mellitus*[13], with the reduction of τ linked to an improvement in this capacity.

There is currently limited literature available describing the behaviour of τ in obese adult patients treated with VSG[14]. For this reason, the aim of this study was to describe the impact of VSG on the VO_2 kinetics of obese women.

Material and method

This study is quasi-experimental, with the participation of 15 women aged 32.9 ± 10.3 years of age; weight, height and starting BMI of 90.2 ± 10.49 kg; 1.6 ± 0.1 m and 35.2 ± 3.9 kg/m^2 respectively. The sample is non-probabilistic, with a group of volunteers, who were assessed at three different points in time: before surgery (pre), as well as 30 and 90 days after surgical intervention (30 post and 90 post respectively). The inclusion criteria correspond to: BMI ≥ 30 kg/m^2, having fulfilled the surgical and anaesthetic criteria in order to undergo BS, and that the mentioned intervention is BS. Excluded patients were all those with previous BS, those with medical co-morbidities such as: chronic respiratory disease, heart disease, chronic liver disease or kidney failure, patients that used beta blockers, smokers, post-menopausal women, and patients that presented muscular-skeletal pathology that prevented them from performing the tests. Research and its protocols were aligned with the guidelines indicated in the 2013 Helsinki Declaration, approved by the Ethics Committee for Research on Humans at the University of Chile Medicine Faculty, Project No. 149-2014; all participants signed a previously informed consent form when their details were taken.

Procedures

Upon arriving at the laboratory, each subject had been previously required to fast for 4 hours and not to perform intense physical activity within the 24 hour period before assessment. The CC was assessed with a ROSSCRAFT® adult tape measure graduated in centimetres, to establish the middle point between the iliac crest and the lowest part of the ribs. Weight and height were measured with a DETECTO 439 (Detecto, Webb City, United States) graduated weighing scale/height measure. BMI was measured to estimate the degree of obesity (kg/m^2).

To measure the cardio-respiratory variables, Metalyzer 3b equipment, Cortex (CORTEX Biophysik, Leipzig, Germany) and a Monark 915E cycle-ergometer (Monark Exercise AB, Vansbro, Sweden) were used. To obtain VO_2 and VO_{2peak} kinetic data, the protocol consisted in the measurement of 2 minutes resting base cardio-respiratory parameters on the cycle-ergometer, then whilst pedalling at a speed of 60 rpm at a constant load of 0.5 watts per kilogram of body weight (W/kg) for 6 minutes to obtain the tau data. After this, to obtain the VO_{2peak} values, the load was increased at steps of 20 or 25 W (depending on the level of physical activity) every two minutes until exhaustion or to the point of reaching a respiratory quotient (RER) ≥ 1.1, perceived exertion ≥ 7 on the modified Borg Scale, or until the subject presented muscle fatigue that prevented the pedal speed from remaining at 60 rpm[15]. Following this, pedalling without load was performed for 3 minutes to cool down. Tau values were established following the protocol described by Poole[16], in which the value was obtained from the 6 first minutes on the cycle-ergometer exercise test. The VO_2 by ventilation values were transformed to obtain values with the 1Hz frequency, to be modelled mathematically in accordance with the equation that defines the VO_2 response, at a constant load and at moderate intensities, described below (Figure 1):

Figure 1. Formula to calculate the oxygen consumption kinetics.

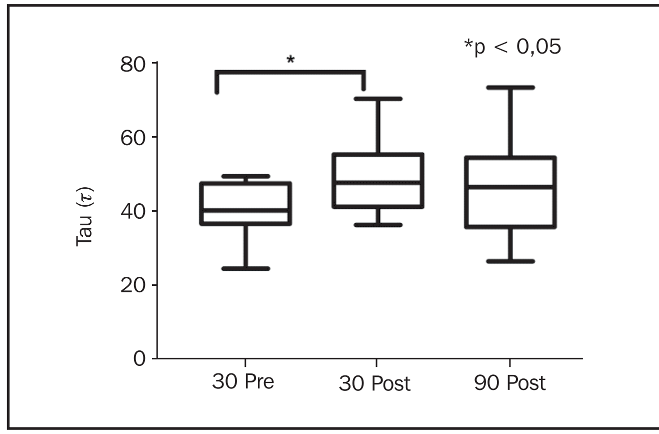
$$\dot{V}O_2(t) = \dot{V}O_2 \text{ basal} + \text{amplitud} \left(1 - e^{-\frac{t-TD}{\tau}}\right)$$

Where $VO_2(t)$ is the VO_2 at any time t, base VO_2 is the VO_2 before starting the exercise, range is the "stable state" towards which the VO_2 is projected, TD is the time delay that precedes the increase in muscular VO_2 and τ is the time constant that describes the rate at which VO2 increases to a stable state[16].

Statistical analysis

The statistical analysis was performed using IBM® SPSS® Statistics software, version 24.0 (Chicago, USA). The continuous variables were expressed as average and standard deviation prior to an analysis of data normality using the Shapiro-Wilk test. Quantitative variable comparisons were established using the ANOVA test of a factor of repeated measures and post-hoc analysis of Bonferroni. The $p<0.05$ values were considered to be statistically significant.

Figure 2. Oxygen consumption kinetics in pre and post vertical sleeve gastrectomy conditions on obese women.



Results

The women presented type II obesity in the assessment prior to surgical intervention (BMI 35.2 ± 3.9 kg/m^2), shifting to a condition of pre-obesity (28.5 ± 3.4 kg/m^2) three months later[17]; significant reductions were reported 30 and 90 days post surgery, in body weight, CC and BMI variables, as well as between *30 post* and 90 post ($p<0.001$) (Table 1).

In relation to relative VO_{2peak} (ml/kg/min), this displayed significant changes between the pre and 90 post periods ($p<0.001$), and in turn, the absolute VO_{2peak} value (L/min) reduced between the pre and *30 post* moments ($p<0.001$) and 90 post ($p<0.002$) (Table 1). In turn, the VO_2 kinetic presented significant differences between the pre and *30post* periods ($p<0.05$) (Figure 2).

Discussion

The aim of this study was to describe the impact of BS on VO_2 kinetic. First off, it is relevant to highlight that in this study, a detailed body composition assessment was not taken into account, whereby the researchers consider it pertinent to express the changes in the CRC values obtained in their absolute form (VO_{2peak} absolute (L/min) as opposed to normalising them by body weight; as such it is brought to light that just 30 days post surgical intervention are enough to present significant deterioration of this capacity; the results obtained are similar to those put forward by Browning *et al*. who analysed the parameters of this variable in obese subjects intervened with BS, affirming an average reduction of 2.6 L/min to 2.4 L/min at 3 months post intervention18. The aforementioned can be explained by the loss of lean mass and not fat mass[19]; on the other hand, significant body weight loss has been verified, associated specifically to predominantly fat mass in the first months following this kind of surgery[20].

With regards to the results of the VO_2 kinetic obtained in this research, it is important to highlight that this variable describes the dynamic response of this gas to sudden changes in the external work rate, proving to be dependent upon the intensity of the exercise when this exceeds the gas exchange threshold[21,22]. The results obtained of the VO_2 kinetic reveal that 30 days after BS, a significant increase can be seen in the stabilisation response time of this variable to the work load imposed by the activity, which indicates a slower fundamental component in the VO_2 kinetic, determining a greater oxygen deficit during the transition of resting to exercise. The results obtained can be compared to those put forward by Neunhaeuserer et al. who also refer to an increase in this variable among obese subjects who have undergone VSG BS[23].

Table 1. Effect of the vertical sleeve gastrectomy on the physical capacities of obese women.

Variables	Evaluations				Bonferroni *(Post hoc)*		
	pre	**30*post***	**90*post***	***p value***	***pre* vs. 30*post***	***pre* vs. 90*post***	**30*post* vs. 90*post***
Weight (kg)	91.5 ± 11.0	82.2 ± 11.2	74.2 ± 9.9	<0.001	9.3 (<0.001) **	17.3 (<0.001) **	8.0 (<0.001) **
BMI (kg/m^2)	35.2 ± 3.9	31.6 ± 3.9	28.5 ± 3.5	<0.001	3.6 (<0.001) **	6.6 (<0.001) **	3.0 (<0.001) **
CC (cm)	109.5 ± 6.7	102.5 ± 7.1	94.9 ± 7.9	<0.001	7.1 (<0.001) **	14.5 (<0.001) **	7.4 (<0.001) **
VO_{2peak} (L/min)	1.9 ± 0.2	1.6 ± 0.3	1.6 ± 0.2	<0.001	0.2 (<0.001) **	0.2 (<0.005) *	-0.05 (0.402)
VO_{2peak} (ml/kg/min)	21.0 ± 3.6	19.6 ± 2.6	22.5 ± 2.8	<0.001	1.3 (0.077)	-1.4 (0.099)	-2.8 (<0.001) **
Tau (τ)	39.8 ± 6.8	48.8 ± 9.5	46.1 ± 12.4	<0.001	-9.0 (<0.005) *	-6.3 (0.124)	2.7 (1.00)

The data is presented as averages and standard deviation, p value, ANOVA Test and Bonferroni Test. Tau (τ): Oxygen consumption kinetics; BMI: Body Mass Index. *p <0.05 **<0.001.

This results highlights that this kind of intervention negatively influences tolerance to exercise, suggesting that an increase in this variable (τ) slows down oxidative muscular metabolism activation[24], which is a possible cause of a lower energy expenditure per activity faced with a reduction of body weight post BS. On the other hand, Simoneau and Kelley highlighted that in subjects with health conditions associated to poor nutrition through overeating, there is a reduced activity of oxidative enzymes and a disproportionate increase of the activity of glycolytic enzymes, which could explain the τ results obtained in this research[25]. In the same sphere, literature has revealed τ values close to ~10 seconds in healthy individuals with a high level of physical training[26] and between 20 to 60 seconds in healthy adults[27]; the publications displayed have described that the increase of oxygen capture at the start of exercise demonstrates the circulatory adjustments to the metabolic modifications induced by this activity, where the oxygen contribution is not a limiting factor of performance during sub-maximum exercise, which reflects efficient muscular bioenergy and an effective tissue-level oxygen diffusion[28], conditions that are not present in subjects with obesity[15]. On the other hand, literature has also revealed τ behaviour in obese adults (without surgical intervention), with data discovered close to 58.7 ± 35.8 seconds[23]; subjects with pulmonary vascular disease 74 ± 16 seconds[29] and with type II diabetes *mellitus* 55.7 ± 20.6 seconds[30]; attributing the increase of this variable to the intensity of physical exercise employed and the capacity of the cardio-respiratory system to respond to the greater demand of this activity. Other antecedents have reported that obese subjects present muscular-skeletal changes both structurally (associated mainly to the higher proportion of type IIb muscle fibres[31]) and to the amount of muscle compared to normal-weight subjects[32], which entails the consequent incapacity to increase the oxidation of fats during β-adrenergic stimulation in exercise, with the subsequent increase of intramuscular fat storage[33]. In turn, with regards to the functioning of the respiratory system, information has been found stating that these subject present a lower flow value upon performing physical exercise, which must be compensated for by increasing the respiratory frequency, accelerating the start of the ventilatory threshold, speeding up the appearance of the slow VO_2 component, infringing upon tolerance of effort and adaptation to physical effort[34].

Conclusion

It is suggested that the VO_2 kinetic increases in obese women intervened with BS 30 days post surgery, therefore, the time needed to stabilise the cardio-respiratory response to work load imposed is slower. The latter is highly useful in clinical terms for the treatment of subjects with this health condition, as it is relevant when it comes to planning physical exercises guidelines for this particular demographic.

Conflict of Interest

The authors claim to have no conflict of interest whatsoever.

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