Original Article

Anthropometric profile, cardiorespiratory capacity and pulmonary function in an elite Chilean triathlete: A case study

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ABSTRACT

The objective of this study was to describe the anthropometric profile, cardiorespiratory capacity and lung function in a high-performance Chilean triathlete ranked first in the national ranking. For this, the body composition profile proposed by Kerr, the somatotype according to Carter and Heath, lung volumes with spirometry according to the criteria of the ATS/ERS, the maximum dynamic inspiratory strength (S-index), the maximum inspiratory flow (FMI) and the maximum oxygen consumption (VO_{2max}) with a treadmill cardiopulmonary exercise test were evaluated. The results showed 50.30% (30.28 kg) of muscle tissue, 21.46% (12.92 kg) of adipose tissue, a musculoskeletal index of 4.4, and a balanced mesomorphic somatotype (ENDO 2.0 – MESO 5.1 – ECTO 2.3). The VO_{2max} was 77 ml/kg/min, the S-Index was 189 cmH_2O, the FIM was 10.1 l/sec, the FEV1 was 4.08 l, maximum voluntary ventilation (MVV) was 153 l and a maximum expiratory flow (FEM) of 584 l. In conclusion, the triathlete has a high level of muscle tissue and optimal percentage of subcutaneous body fat with a balanced physical form towards the muscle component. An outstanding cardiorespiratory capacity, inspiratory strength and lung function represents a great adaptation to the endurance tests that make up triathlon, especially swimming on inspiratory strength. Morphofunctional changes associated with the high-performance sports discipline are observed.
Keywords: Performance analysis of sport, Body composition, Somatotype, Triathlon.

Cite this article as:
Yáñez-Sepúlveda, R., Cortés-Roco, G., Rivera-Kofler, T., Báez-San Martín, E., & Tuesta, M. (2023). Anthropometric profile, cardiorespiratory capacity and pulmonary function in an elite Chilean triathlete: A case study. *Journal of Human Sport and Exercise, 18*(4), 775-785. https://doi.org/10.14198/jhse.2023.184.03

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Submitted for publication March 15, 2023.
Accepted for publication March 28, 2023.
Published October 01, 2023 *(in press* April 28, 2023).
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202.

doi:10.14198/jhse.2023.184.03

INTRODUCTION

Triathlon is an energy-intensive sport that combines swimming, cycling and jogging. Performance in this sport discipline depends on various factors such as body composition, VO_{2max} and respiratory parameters among others (Cuba et al., 2022) so describing these variables is a main factor when programming training. This sport requires a high physical demand due to the high volumes of training involved in its practice (Etxebarria et al., 2019). In recent years there has been an increase in the practice of triathlon at a competitive level (Sellés et al., 2019). Despite its growing practice, there is little evidence in Chile on morphofunctional profiles, VO_{2max} and lung function in high-performance triathletes in this discipline. Although there is literature history of body composition profiles in triathletes, there is little evidence regarding lung function and maximal dynamic inspiratory strength.

In Triathlon, body composition is directly related to physical performance. An excess of adipose tissue and body weight is disadvantageous in the running, cycling and swimming segment (Sellés et al., 2019). In long-distance triathletes, lower rates in the endomorphy component of the somatotype, as well as higher rates in the ectomorphy component have resulted in significantly better performance in the Ironman race (Kandel et al., 2014). Cardiorespiratory fitness, in terms of VO_{2max} and ventilatory thresholds, are the strongest predictors of triathlon performance. This response can be affected depending on the triathlon segment performed and the age or sex of the athlete, leading to both physiological and biomechanical alterations that affect competition performance (Borrego et al., 2021) Elite triathletes have VO_{2max} values. significantly higher than subelite triathletes, and high levels of VO_{2max} are required. to succeed in this sport (Knechtle et al., 2015). On the other hand, the performance of the respiratory muscles, defined as the ability of the respiratory muscles to achieve contractile functions, depends on strength and endurance. The inspiratory force is evaluated from the transdiaphragmatic contraction pressures (Boussana et al., 2020) and is considered an important marker of ventilatory capacity and a predictor of overall performance, with the S-Index being a tool to dynamically evaluate the maximum inspiratory pressure (Silva et al., 2018). The high intensity demanded by the practice of triathlon could affect the capacity of the respiratory muscles. Boussana et al. evaluated respiratory muscle fatigue induced by an Olympic distance triathlon in nine male triathletes. The results of the study allowed us to conclude that a triathlon race induced a 30.5% decrease in the resistance of the inspiratory muscles in triathletes after the race and that 24 hours later it remained decreased by 24.7%. This shows the importance of assessing respiratory function in triathletes and also considering the specific training of inspiratory muscles during triathlon training sessions (Boussana et al., 2020). Based on the above, the objective of this study was to describe the anthropometric profile, cardiorespiratory capacity, and lung function in an elite Chilean triathlete.

MATERIALS AND METHODS

Participant

A 22-year-old triathlete ranked first in Chile with experience in national and international competitions in the 70.3® modality was evaluated.

Assessments

The evaluations were carried out in a room with an ambient temperature of between 18 and 22º Celsius heated by an electrical system.

Body composition

The evaluation was carried out with a minimum fast of 4 hours, after urinary emptying, 48 after performing physical exercise of moderate to vigorous intensity, without having consumed caffeine or alcohol 24 hours before the evaluations and without being dehydrated (Carrión et al., 2019). Body weight was calculated with a digital scale with accuracy of 100 grs (803, SECA®, France)Standing and sitting height was evaluated barefoot with a SECA® stadiometer (accuracy 0.1 cm), bone diameters were measured with a short anthropometer and a long anthropometer from the anthropometry kit (Health & Performance®, Chile) with a plicometer (Harpenden®, UK, sensitivity of ± 0.5mm, pressure ± 10 g/mm^2 and repeatability of 0.20 mm) were evaluated skinfolds and a tape measure (Lukfin®, United States, sensitivity of 1mm) was used for the assessment of the perimeters. The evaluation was performed by a professional certified by the International Society for Advancement of Kinanthropometry (ISAK) and restricted profile was used (Marfell-Jones, 2006). The following 27 variables were evaluated, basic measures (3): sitting height (cm), standing height (cm) and weight (kg), diameters (mm) (6): biachromial, transverse thorax, anteroposterior thorax, biiliocrestid, humeral and femoral, perimeters (cm) (10): head, relaxed arm, arm flexed in tension, forearm, mesosternal thorax, waist, hip, maximum thigh, medial thigh and calf. Skin folds (mm) (8): biceps, triceps, subscapular, suprailiac, supraspinal, abdominal, frontal thigh and medial leg. The body composition profile is then calculated with the pentacompartmental proposed by Kerr (1988) that allows to divide the body into five components (muscle, fat, bone, skin and residual), the somatotype was analysed based on the model of Heath and Carter (Carter & Heath, 1990). The bone muscle index (BMI) is calculated by dividing muscle tissue with bone tissue in kg. These anthropometric components were obtained from a computational anthropometric program (5Componentes®, Chile).

Lung function

Pulmonary flow and volumes were evaluated with spirometry based on the criteria of the American Thoracic Society (ATS) and the European Respiratory Society (ERS) (Graham et al., 2019; Miller et al., 2005). A portable spirometer from the manufacturer Viasys Healthcare model Microlab® (USA) previously calibrated with a 3L syringe was used. the pulmonary function variables FEV1 (l), FVC (l), PEF (l/m), FEV1/FVC (%), FEF25%-75% (l/s) and MVV (l/min) were obtained, MVV was obtained by multiplying FEV1 x 37.5. The evaluation was performed in a sitting position in a chair fixed to the floor, before the evaluation a nose clip was installed to each individual, which should be kept on while inspiration and expiration was performed to its maximum capacity (Stanojevic et al., 2022). For the analysis of the results, the best values obtained were used considering compliance with the ATS/ERS criteria. The data were manually transferred to an Excel spreadsheet after checking the quality criteria of these.

Maximum dynamic inspiratory force

Maximum dynamic inspiratory strength (S-index) and maximum inspiratory flow (MIF) at rest (Yañez et al., 2021) were evaluated with a flowmeter (POWERbreathe Kinetic K5®, HaB International Ltd, UK). After a process of familiarization about the use of the device and in order to avoid the learning effect, a warming of the respiratory muscles was carried out (Volianitis, McConnell, & Jones, 2001). Then, starting from the residual volume, each subject sitting in a chair fixed on the floor and with a nose clip, made a maximum of 10 maximum inspiratory efforts, from these efforts the values of the 3 best efforts were chosen without differences greater than 10% between them for the analysis of the results. In this study, a rest interval during evaluation was considered between 1 to 1.5 minutes between consecutive efforts.

Maximum oxygen consumption (VO_{2max}) and ventilatory thresholds (VT)

VO_{2max} was evaluated in a treadmill test until exhaustion (McConnell, 1988). A gas analyser (Cortex Metalizer®, Germany) was used and pre-calibrated with a 3l syringe. The protocol used was incremental based on the recommendations of Gerkin (Mier & Gibson, 2004), this test is validated for runners and athletes, has 14 stages, the first of 3 minutes and the remaining 1 minute and begins with a speed of 3.5 mph. VO_{2max} is calculated with VO_2 plus High obtained for any continuous period of 1 min. The first ventilatory threshold (VT1) was determined using the criterion of increase of both EV/VO_2 and $PETO_2$ without increase in EV/VCO_2, while the second ventilatory threshold (VT2) was determined using the criteria of increase of both EV/VO_2 and EV/VCO_2 and decrease of $PETCO_2$ (Cejuela & Sellés-Pérez, 2022).

Ethical considerations

All evaluations were conducted with informed consent following the recommendations of the Declaration of Helsinki (World Medical Association, 2013) for human studies. The procedures to be performed were exposed and socialized in a meeting prior to data collection.

Statistical analysis

To describe the study variables, the mean obtained from the evaluations was used. The anthropometric data were taken manually and then transferred to an Excel® spreadsheet, the calculation of the components of body composition were calculated with the 5 components® software. Data on lung function, maximal inspiratory dynamic strength and VO_{2max} were manually extracted from the equipment used for the assessments.

RESULTS

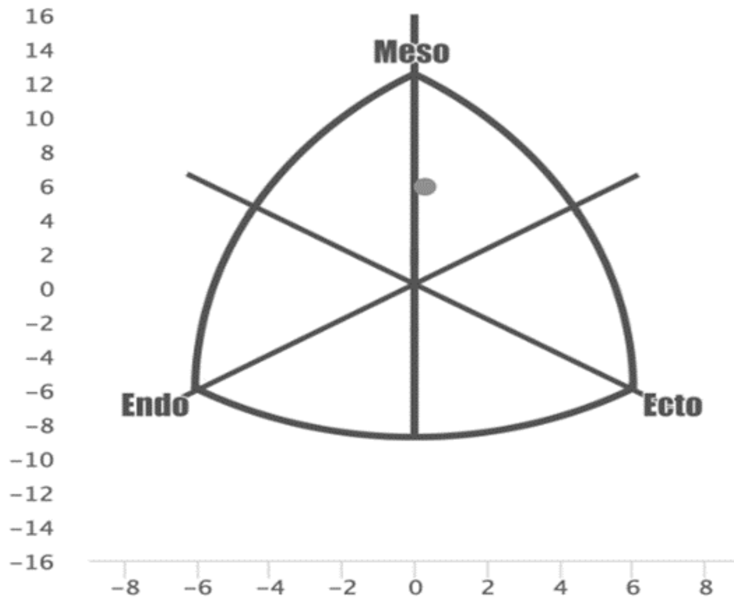
Below are the results obtained in the anthropometric profile, somatotype, pentacompartmental fractionation, lung function and VO_{2max} of the athlete.

Table 1 shows a body weight of 60.2 kg and a height of 165cm. The anthropometric variables considered in the study are also appreciated.

General data	Value
Basic measures	
Weight (kg)	60.2
Age (years)	22
Size (cm)	165
Sitting Size (cm)	88
Skinfolds thickness(mm)	
Triceps (mm)	7
Subscapular (mm)	8
Biceps (mm)	3
Iliac crest (mm)	12
Supraspinal (mm)	5
Abdominal (mm)	16
Thigh (mm)	5
Leg (mm)	7
Perimeters (cm)	
Head (cm)	55.5
Relaxed arm (cm)	27.5
Flexed and contracted arm (cm)	31
Forearm (cm)	25.5
Thorax (cm)	90

Waist (cm)	74.5
Hips (cm)	90.5
Middle thigh (cm)	52.5
Leg (cm)	34.5
Diameters (cm)	
Biacromial (cm)	37.3
Biiliocrestal (cm)	25.8
Transverse chest (cm)	28.7
Antero-posterior chest (cm)	18
Humerus (cm)	6.5
Femur (cm)	9.2

Figure 1 shows that the triathlete presents a somatotype with a balanced mesomorph classification.



Note. ENDO: 2.1 – MESO: 5.1 – ENDO: 2.3 (Balanced Mesomorph).

Figure 1. Triathlete's Somatocarta.

The main results showed a balanced mesomorphic somatotype (ENDO: 2.0 - MESO: 5.1 - ECTO 2.3) with 50.3% (30.28 kg) of muscle tissue, 21.46% (12.92 kg) of adipose tissue and musculoskeletal index of 4.40 (Figure 2).

Figure 3 shows a greater distribution of adipose tissue in the middle zone (44%) and a greater distribution of muscle tissue in the lower zone (43%).

Table 2 shows the variables of physical capacity and lung function we find a VO_{2max} of 77 ml/kg/min, VT1 (62.3% VO_{2max}) and VT2 (88.3% VO_{2max}), S-index of 189 cmH_2O, flow of 10.1 l, FEV1 of 4.08 l and FVC of 4.75 l, there is also a PEF of 584 l.

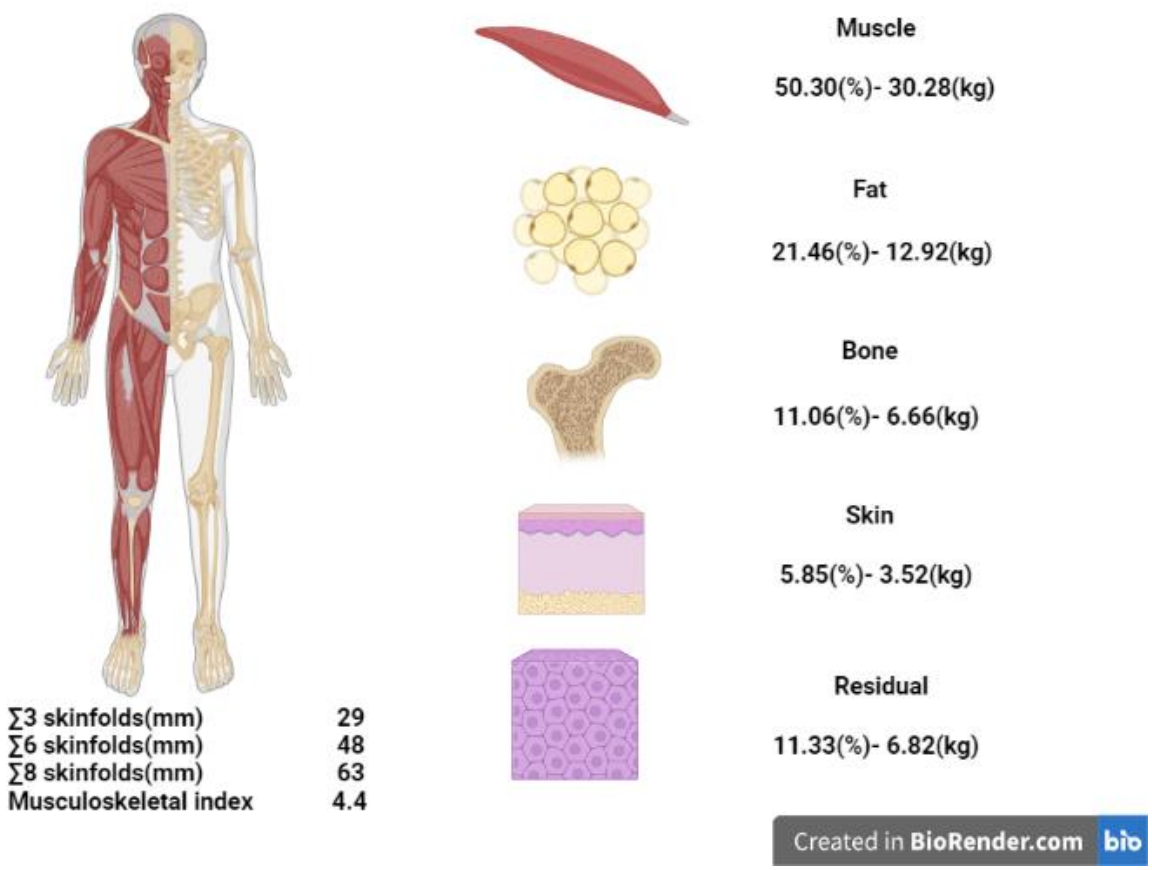


Figure 2. Penta compartmental fractionation, fold summation and musculoskeletal index of the triathlete.

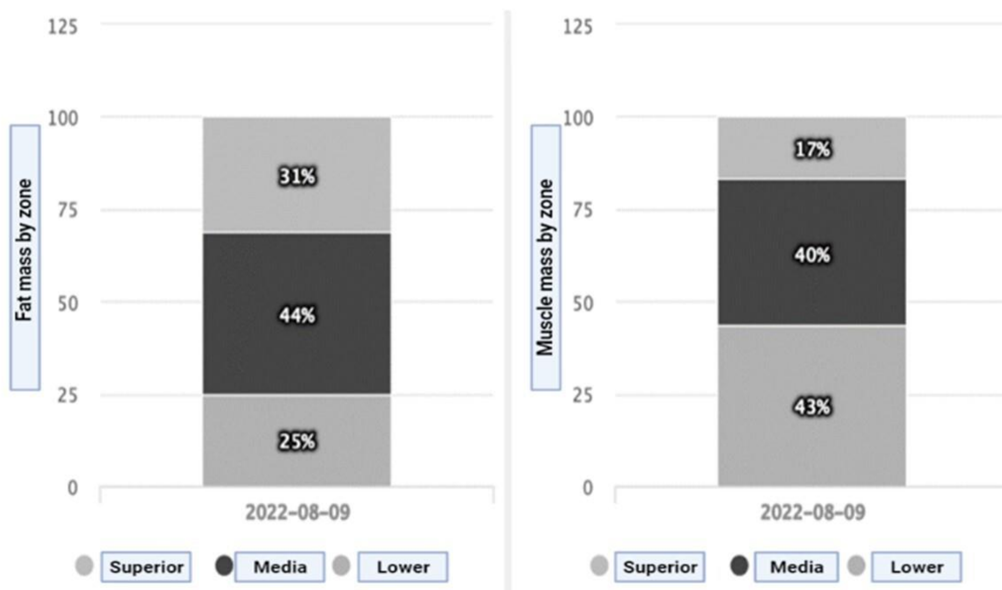


Figure 3. Distribution of adipose and muscle mass by zones.

Table 2. Pulmonary function variables and VO_{2max} in the triathlete.

Variable	Value
Inspiratory power	
S-Index (cmH_2O)	189
Flow (l)	10.1
Volume (l)	4.0
Spirometry	
FEV1 (l)	4.08
FVC (l)	4.75
PEF (ls^{-1})	584
FEV /FVC	86
FEF 25%-75% (ls^{-1})	4.43
MVV (l/min)	153
Cardiorespiratory capacity	
VO_{2max} (ml/kg/min)	77
UV1 (%VO_{2max})	62.3
UV2 (%VO_{2max})	88.3

Note. S-Index: maximum dynamic inspiratory force; FEV1: forced spiroatom volume in the first second; FVC, forced vital capacity; PEF, peak expiratory flow; FEV/FVC: relationship between FEV and FVC; FEV 25%-75%: flow measured between 25% and 75% of the forced expiration manoeuvre; MVV: maximum voluntary ventilation; VO_{2max}: maximum oxygen consumption; UV1: first ventilatory threshold; UV2: second ventilatory threshold.

DISCUSION

According to the objective of the present study, the results show that the elite triathlete presents a VO_{2max} value similar to those reported in the literature, high values of maximum inspiratory dynamic strength, and a balanced mesomorphic anthropometric profile.

Body composition and somatotype

Anthropometric characteristics are of great importance to the performance of the Ironman race. In the variables of body composition, the literature has reported values similar to those found in our study in what corresponds to the percentage of body fat 21.4% vs 21.2% (Millet & Bentley, 2004) and 21.4% vs 19.8%. Body mass, mass index, and lower body fat are associated with shorter times in the Ironman (Canda et al., 2014). When comparing the results obtained in an Olympic triathlete with the results obtained in the present study, a sum of 6 folds greater in our athlete (48 mm vs 34 mm) can be appreciated, this can be conditioned by the age of our athlete and the level of experience (Cejuela & Sellés-Pérez, 2022). The muscle mass of our triathlete is located on the percentage values reported in university triathletes percentage of muscle mass (50.3% vs 45.27%) (Guillén et al., 2015), a study conducted on Swiss triathletes found an average body weight of 77.8 and muscle mass values of 41.0kg (Knechtle et al., 2010). Regarding the somatotype, the results are similar to those described in the literature (2.0-5.1.2.3 vs 3.1-4.3-2.6) (Leake & Carter, 1991) with a higher level of mesomorphy in the results obtained in our study, as in the comparison with another reported study (2.0-5.1.2.3 vs 1.7-4.9-2.8) (Kandel et al., 2014). The same research work showed that the somatotype was a strong predictor of running performance in an Ironman, in male athletes, endomorphy being the most important predictor of performance, since the greater the endomorphy, the lower the performance in the race (triathlon-Ironman), it was also observed that an increase in the ectomorphic component (i.e., having a light and lean body structure) leads to significant improvements in Ironman performance (Kandel et al., 2014).

Finally, as evidenced by another study, a decrease in fat mass and a lower value of the endomorphic component were related to higher values of relative VO_{2max} (Sélles et al., 2019).

Maximal dynamic inspiratory strength and lung function

In the pulmonary function variables, values higher than those reported in triathletes (189 cmH_2O vs 127 cmH_2O) (Boussana et al., 2020) and other sports such as handball (189 cmH_2O vs 173 cmH_2O) (Hartz et al., 2018), 800-meter runners (189 cmH_2O vs 131 cmH_2O) (Ohya et al., 2016) and junior swimmers (189 cmH_2O vs 124 cmH_2O) (Yáñez-Sepúlveda et al., 2021). The importance of assessing respiratory muscle endurance as an influential factor in triathlon performance is evidenced by the study by Boussana et al., where they evaluated respiratory muscle fatigue induced by an Olympic distance triathlon in nine male triathletes. The maximum inspiratory pressure decreased significantly from 127.4 ± 17.2 cmH2O (pre-T) to 121.6 ± 18.5 cmH_2O (post-T) and returned to the pre-T value 24 hours after the race (125.0 ± 18.6), noting that both the strength and endurance of the inspiratory muscles decrease after a triathlon race (Boussana et al., 2020). Fatigue of the inspiratory muscles is due according to reports from different studies preferably to the high intensity of exercise (>85% VO_{2max}) (Smith et al., 2014)

Maximum oxygen consumption (VO_{2max}) and ventilatory thresholds (UV)

High values of maximum oxygen consumption (VO_{2max}) have been linked to performance levels in ultra-endurance races (Sellés et al., 2019). The triathlete evaluated has higher levels of VO_{2max} than those reported in various studies (77 ml/kg/min vs. 69.9 ml/kg/min (Schabort et al., 2000), 65.6 ml/kg/min (Laurenson et al., 1993), 64.4 ml/kg/min (Hue et al., 2006) and 69.7 ml/kg/min (Baldari et al., 2005), but lower than the results obtained in an Olympic-level triathlete (81.8 ml/kg/min vs 77 ml/kg/min) (Cejuela & Sellés-Pérez, 2022). In the review by Knechtle et al. summarizing the findings of performance in triathlon and seeking to determine possible predictors of performance in male and female triathletes, VO_{2max} in maximum exercise was for men 68.8 ml/kg/min on treadmill and 66.7 ml/kg/min on cycle ergometer (Knechtle et al., 2015). Another important variable to consider is the ventilatory thresholds (UV), when comparing the results of our study with those obtained in a study conducted in highly trained triathletes, the triathlete participating in the present study had higher $\%VO_{2max}$ when reaching UV1 and UV2 respectively (UV1 62.2 vs 56% in UV1 and 88.3 vs 86.2% in UV2) (Zapico et al., 2014).

CONCLUSION

In conclusion, the triathlete has a high level of muscle tissue and optimal percentage of subcutaneous body fat with a balanced physical form towards the muscle component. An outstanding cardiorespiratory capacity, inspiratory strength and lung function represents a great adaptation to the endurance tests that make up triathlon, especially swimming on inspiratory strength. Morphofunctional changes associated with the high-performance sports discipline are observed. According to what was observed, improvements in lung function through the training of the respiratory muscles could be an effective alternative for the improvement of sports performance in this case that favour its development in this sports discipline, the results of this study can be used by professionals of physical exercise and sports nutrition in decision making.

AUTHOR CONTRIBUTIONS

Conceptualization, R. Y. S., G. C. R., and M. T.; methodology, R. Y. S., G. C. R., T. R. K., and M. T.; software, R. Y. S., G. C. R., T. R. K., E. B. S., and M. T.; validation, T. R. K., E. B. S., and M. T.; database analysis, R. Y. S., G. C. R., and E. B. S.; resources, R. Y. S., T. R. K., E. B. S., and M. T.; data validation, E. B. S., and M. T.; analysis, R. Y. S., and G. C. R.; writing and original draft preparation, R. Y. S., G. C. R., T. R. K., E. B.

S., and M. T.; writing, review, and editing, R. Y. S., G. C. R., T. R. K., E. B.S., and M. T.; supervision E. B. S., and M. T., project administration; R. Y. S. All authors have read and agreed to the published version of the manuscript.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest were reported by the authors.

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