Relationship of Abdominal Perimeter with Epicardial and Pericardial Fat

Relação do Perímetro Abdominal com a Gordura Epicárdica e Pericárdica

Hugo Duarte
School of Health Dr. Lopes Dias, Polytechnic Institute of Castelo Branco, BSc Student, Portugal.

Carlos Alcafache
Hospital Nossa Senhora da Assunção – ULS Guarda, Escola Superior de Saúde, Dr. Lopes Dias, Instituto Politécnico de Castelo Branco, BSc, Portugal.

Ana Carolina Santos
Nossa Senhora da Assunção Hospital - ULS Guarda, School of Health BSc, Portugal.

Patrícia Coelho
Sport, Health & Exercise Unit (SHERU) | Quality of Life in the Rural World (QRural), Polytechnic Institute of Castelo Branco, PhD, Portugal.

Francisco Rodrigues
Quality of Life in the Rural World (QRural) | Sport, Health & Exercise Unit (SHERU), Polytechnic Institute of Castelo Branco, PhD, Portugal.

Joana Pires
Dr. Lopes Dias School of Health, Polytechnic Institute of Castelo Branco, MSc, PhD Student, Portugal.

ABSTRACT
Diastolic heart failure is one of the major causes of morbidity and mortality and is preceded by left ventricular (LV) diastolic dysfunction, and is often associated with obesity and/or diabetes Mellitus 2 . (De Wit-Verheggen et al., 2020; DeFronzo et al., 2015; Fontes-Carvalho et al., 2015; Ma et al., 2021; Son et al., 2016)

Keywords: Abdominal Perimeter, Epicardial, Pericardial, Fat.

RESUMO
A insuficiência cardíaca diastólica é uma das maiores causas de morbilidade e mortalidade e é precedido por disfunção diastólica do ventrículo esquerdo (VE), estando muitas vezes associado com obesidade e/ou diabetes Mellitus 2 (De Wit-Verheggen et al., 2020; DeFronzo et al., 2015; Fontes-Carvalho et al., 2015; Ma et al., 2021; Son et al., 2016).

Palavras-chave: Perímetro Abdominal, Epicárdica, Pericárdica, Gordura.

1 INTRODUCTION

Diastolic heart failure is one of the major causes of morbidity and mortality and is preceded by left ventricular (LV) diastolic dysfunction, and is often associated with obesity and/or diabetes Mellitus 2 . (De

Wit-Verheggen et al., 2020; DeFronzo et al., 2015; Fontes-Carvalho et al., 2015; Ma et al., 2021; Son et al., 2016)

In several studies, the importance of evaluating LV diastolic function in a timely manner in order to prevent undesirable outcomes is addressed. The awareness that about half of the individuals with signs and symptoms of heart failure did not have systolic dysfunction, but diastolic dysfunction, alerted to the need for an assertive and timely diagnosis of this clinical condition. LV diastolic dysfunction is usually defined as an abnormal relaxation of the left chamber that can be assessed and quantified through echocardiographic measurements and through diastolic dysfunction algorithms created by the American Society of Echocardiography and the European Association for Cardiovascular Imaging (ASE/EACVI). (Kenchaiah et al., 2021) (Lang et al., 2015; Mitchell et al., 2019; Nagueh et al., 2016)

Obesity is also one of the major causes of morbidity and mortality in the world, due to the increase and abnormal distribution of visceral fat that, depositing in the myocardium and arteries, is severely correlated with cardiovascular diseases. The pericardial fat as described in several bibliographical references is a fat that accumulates in the pericardium that, when in excess, compresses the myocardium leading to a limited distensibility and consequent cardiac remodeling, thus providing diastolic dysfunction. Individuals who have high body mass indexes, obesity and/or diabetes Mellitus 2 are therefore more predisposed to diastolic dysfunction. Considering the pathophysiology of the conditions in question, there is a possible relationship between the abdominal perimeter, the increase in pericardial and epicardial fat and LV diastolic dysfunction. Several studies have been done in order to evaluate this relationship. (Hirata et al., 2018; Okura et al., 2015) (De Wit-Verheggen et al., 2020; Hirata et al., 2018; Ma et al., 2021) (Joseph et al., 2022) (Fontes-Carvalho et al., 2015; Son et al., 2016)

A study similar to the current one was conducted in 2021, in which the abdominal perimeter was measured using a tape measure and a transthoracic echocardiogram was performed for subsequent measurement of pericardial fat thickness and a CT scan for subsequent evaluation of abdominal and subcutaneous fat. Subsequently, a correlation was made between the abdominal perimeter, abdominal fat, pericardial fat and subcutaneous fat. The authors then concluded that there is a positive correlation between abdominal girth and increased pericardial fat, however it was reported that further study of this condition was needed (Nor Et al., 2021) .

In another 2021 study, slightly different methodologies were applied, assessing pericardial fat thickening and LV diastolic function in healthy individuals, respectively. In this case, the abdominal perimeter was not measured and instead it was intended to evaluate the influence of fat around the heart on LV diastolic function. There were two measurements of fat, one performed in the extension of the aortic root line, perpendicular to the free wall of the right ventricle and the other in the maximum thickness of the fat perpendicular to the free wall of the right ventricle, both made with the structure in diastole. In this case,

an increase in the E/e' parameters was observed, and a decrease in the e' septal, e' lateral and E/A parameters in individuals with higher fat around the heart. They concluded that not only is there a correlation between pericardial fat and diastolic dysfunction, but the maximum thickening measured perpendicular to the free wall of the right ventricle has more correlation with diastolic dysfunction, presupposing greater attention to this type of fat. (Ma Et al., 2021)

As this topic is the target of few studies, despite the unequivocal interest, uncertainties arise as to whether there is a relationship between the increase in fat around the heart and the increase in abdominal girth.

2 GOAL

The aim of this study is to relate the abdominal perimeter with the fat around the heart, protagonist in the development of diastolic dysfunction, so that in the future it is possible based on the measurement of the abdominal perimeter to anticipate the development of diastolic dysfunction and consequent diastolic heart failure.

3 METHODOLOGY

3.1 STUDY DESIGN

This is a cross-sectional, observational, prospective and quantitative study. All sample data were collected in the echocardiography laboratory of the Cardiology Service of the Hospital Nossa Senhora da Assunção in Seia – ULS Guarda, between the periods of August 2022 and December 2022.

3.2 SAMPLE

The sample of this study is of the non-probabilistic type by rational choice, counting therefore with all the individuals who performed for convenience echocardiographic study at the Hospital Nossa Senhora da Assunção in Seia. All individuals with systolic dysfunction, cardiomyopathies, significant valvular pathology or patients with intracardiac devices were excluded. Taking into account the above criteria, a sample of 82 individuals was collected. The individuals were divided into two groups, according to their abdominal perimeter: normal and elevated.

3.3 STUDY PROTOCOL

The procedure for data collection was performed in two different steps: the first was the measurement of the abdominal perimeter using a tape measure and the second by performing transthoracic echocardiogram in a Toshiba® equipment, model Xario XG®, using a probe of frequency 2.4 – 4.5 MHz.

Abdominal perimeter was measured around the abdomen just above the navel. We used the cut-off values of the abdominal perimeter recommended by the World Health Organization (WHO) for the separation of the groups, in which it is considered normal when it is below or equal to 88 cm for females and 102 cm for males, considering that above these values there is a higher associated cardiovascular risk. This measurement was always performed by the same professional in order to standardize the method, obtain more accurate measurements and reduce biases. (Andrade & Rojas, n.d.; Wharton et al., 2020; World Health Organization. Regional Office for Europe, n.d.)

Subsequently, a transthoracic echocardiogram was performed, following the most recent guidelines of the American Society of Echocardiography and the European Association of Cardiovascular Imaging, in order to measure the thickness of fat around the myocardium.

It was measured through the window parasternal long axis and parasternal short axis at the level of the papillary muscles, pericardial fat and epicardial fat in the free wall of the right ventricle both in telesystole and using the average of three consecutive beats. An average of the pericardial fat thickness of all individuals was made, in order to use this value as a cut-off, thus allowing the separation of the sample into two groups: High pericardial fat indexes and low pericardial fat indexes. (Eroğlu, 2015)

3.4 COLLAPSED VARIABLES

In order to achieve the objective of the study, several quantitative variables were collected, such as age, weight, height, abdominal perimeter, epicardial and pericardial fat thickness. Qualitative variables such as sex and race were also collected.

3.5 STATISTICAL ANALYSIS

In order to test the distribution of the sample, the Kolmogorov-Smirnov normality test was applied. The T-Student test was used to compare the two groups of abdominal perimeter with the thickness of epicardial and pericardial fat, and also the Spearman test to better perceive the association of the abdominal perimeter with both fats.

For the statistical treatment of qualitative variables, a descriptive analysis was performed using relative frequencies (%), absolute frequencies (n) and measures of central tendency (mean) and dispersion (standard deviation).

The data related to the sample were entered, analyzed and treated using the statistical analysis software IBM SPSS Statistics® (Statistical Package for the Social Sciences) version 27. A p-value less than or equal to 0.05 was defined as statistically significant for all tests.

3.6 ETHICS

The research work was initiated after approval by the Ethics Committee of the Cardiology Service of the Hospital Nossa Senhora da Assunção in Seia – ULS Guarda, which has the approval number 98/2022.

This study respected all ethical principles ensuring the confidentiality of data, results and interpretations. All information obtained in the scope of the research is confidential, and only the personal data strictly necessary to carry out the study were collected. All data collected were used solely for academic purposes and in the context of research.

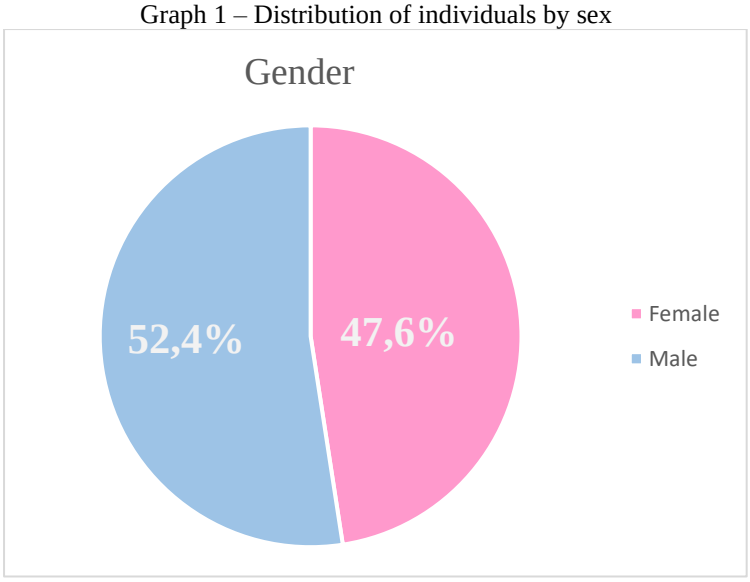
The investigation team declares that it has no conflicts of interest and undertakes to respect the principles expressed in the Declaration of Helsinki. This research is not for profit or commercial.

4 FINDINGS

4.1 SAMPLE CHARACTERIZATION

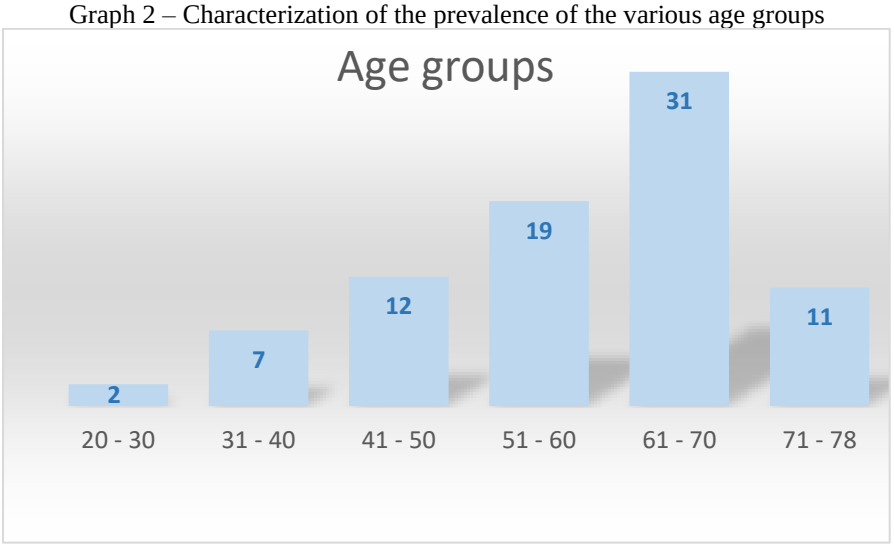
The study sample consisted of 82 Caucasian individuals, corresponding to 47.6% (n= 39) females and 52.4% males (n=43).

Graph 1 – Distribution of individuals by sex



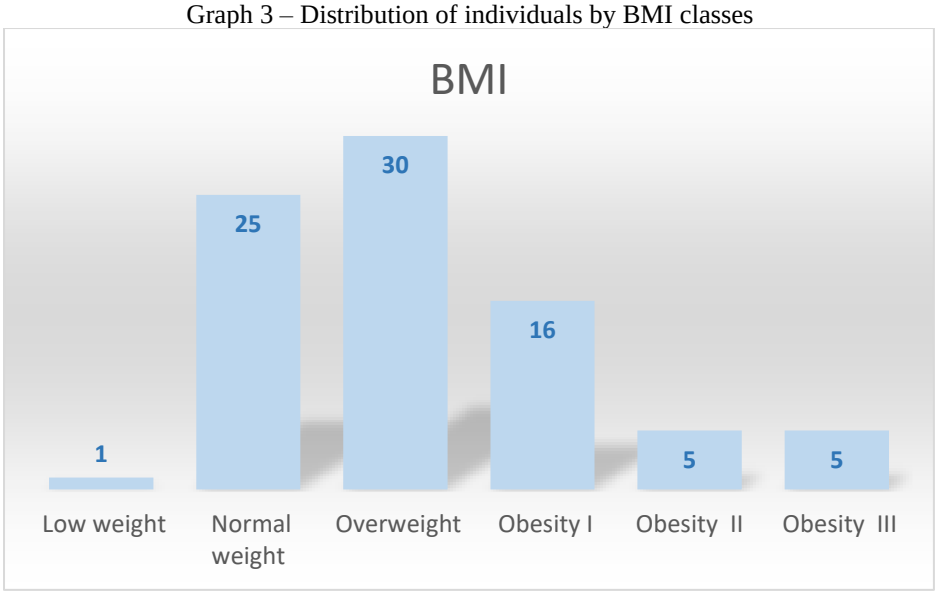
In the analysis of the distribution of individuals by age, it was noticed that these were constituted by ages between 20 and 78 years corresponding to an average of 58.04±2.811 years. It can be observed that the largest number of individuals was in the age group of 61 to 70 years, which was composed of 31 individuals.

Graph 2 – Characterization of the prevalence of the various age groups



In terms of anthropometric profile, the individuals have an average weight of 79.6±25.8 kg, with a maximum of 175 kg and a minimum of 45 kg, an average height of 164.9±9.504 m with a maximum of 198 cm and a minimum of 147cm and an average BMI of 29.2±8.495 kg/m2, with a maximum of 68.7 kg/m2 and a minimum of 18.3 kg/m2. In the BMI classes, overweight was the most prevalent class found in these individuals, constituting 36.6% of the sample (n=30). These are also characterized by having a maximum abdominal perimeter of 125 cm and a minimum of 64 cm, corresponding to an average of 94.787±13.304 cm.

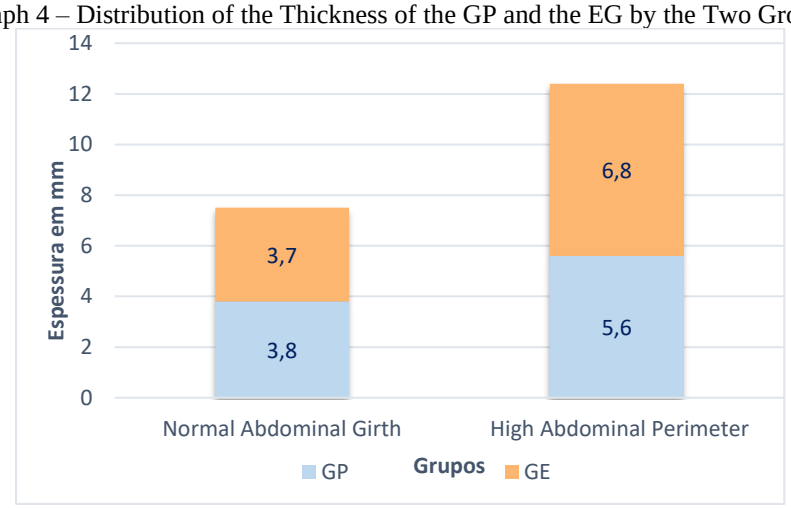
Graph 3 – Distribution of individuals by BMI classes



Of the 82 individuals, 46.3% (n=38) belonged to the high abdominal perimeter group and 53.7% (n=44) to the normal abdominal perimeter group. The group with normal abdominal perimeter has an

average of 3.8 mm (± 1.7 mm) of pericardial fat thickness, with a minimum value of 1.4 mm and a maximum of 9.1 mm, while the group with a high abdominal perimeter has an average of 5.6 mm (± 2.2 mm) of pericardial fat thickness, with a minimum value of 1.9 mm and a maximum of 11.6 mm. The sample is also characterized by a maximum epicardial fat thickness of 7.6 mm and a minimum of 1.5 mm, corresponding to an average of 3.7 mm (± 1.5 mm) in the group of normal abdominal perimeter and a maximum epicardial fat thickness of 13.1 mm and minimum of 2.4 mm, corresponding to an average of 6.8 mm (± 2.8 mm) in the group with high abdominal perimeter.

Graph 4 – Distribution of the Thickness of the GP and the EG by the Two Groups



Legend: EG – Epicardial Fat Thickness expressed in mm; GP – Pericardial Fat Thickness expressed in mm.

All individuals present as a common characteristic preserved ejection fraction, so that this does not influence in any way the diastolic function.

4.2 RELATIONSHIP OF PERICARDIAL FAT AND ABDOMINAL PERIMETER

Table 1 shows that individuals with high abdominal perimeter had higher values of pericardial and epicardial fat compared to individuals belonging to the group of normal abdominal perimeter, this difference was statistically significant (p<0.0001) for both fats.

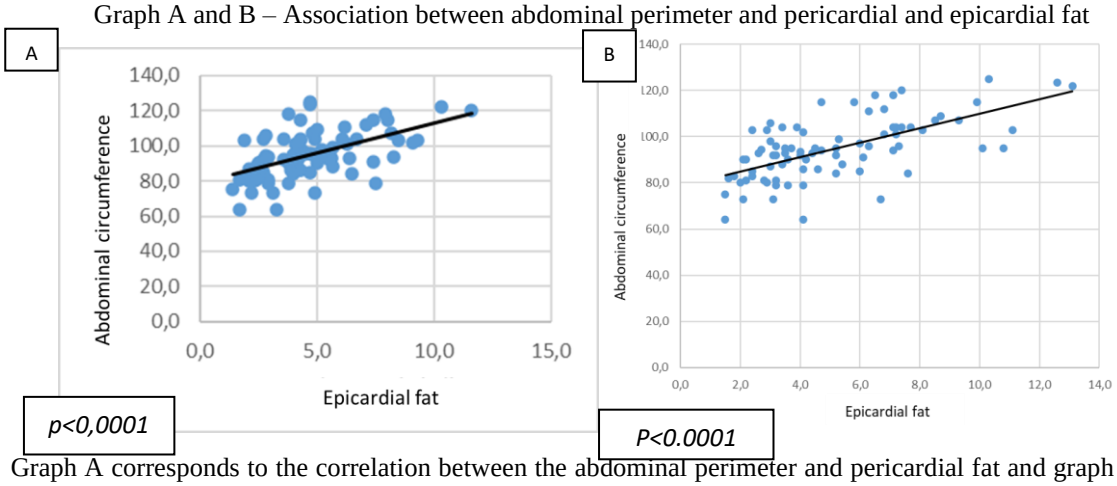
Table 1 – Relationship between the abdominal perimeter and the two groups of pericardial fat.

	Abdominal Girth		(p-value)
	Normal (53.7%)	High (46.3%)	
GP (mm)	3.8 ± 1.7	5.6 ± 2.2	(p<0,0001)
GE (mm)	3,7 ± 1,5	6,8 ± 2,8	(p<0,0001)

The Spearman correlation test was also used to better understand the association between the abdominal perimeter and pericardial and epicardial fats.

In graphs A and B we can observe the correlation that exists between the abdominal perimeter and the fats around the heart through a scatterplot with the appropriate significance (*p<0.0001)*).

Graph A and B – Association between abdominal perimeter and pericardial and epicardial fat



Legend: Graph A corresponds to the correlation between the abdominal perimeter and pericardial fat and graph B corresponds to the correlation between the abdominal perimeter and epicardial fat.

5 DEVELOPMENT

The measurement of the abdominal perimeter is a measure of extreme importance for the clinician, being a relevant indication regarding cardiovascular risk. It is known that the high abdominal girth increases the predisposition to the onset of heart disease due to the accumulation of fat around the heart. The increase in fat around the heart results in a barrier to the normal functioning of the myocardium causing a cardiac remodeling. The abdominal perimeter is thus an independent risk factor, which presupposes the development of diastolic dysfunction . (Fontes-Carvalho et al., 2015; Hirata et al., 2018; Son et al., 2016)

The objective of this study was to better understand the influence that the increase in abdominal perimeter has on the fat around the heart, resorting to transthoracic echocardiography.

As pointed out in the literature, and in corroboration with the results found, a statistically significant increase in abdominal perimeter was observed in the group of individuals with higher pericardial fat indexes. This relationship can be explained by Amir A. Mahabadi et al. as having a decrease in adiponectin production compared to the increase in visceral fat. Adiponectin is an inhibitory stabilizing hormone of NF-kB, released by pericardial fat. This decrease will increase the activation of NF-kB, consequently increasing the production of TNF-a leading to greater local inflammation and subsequent molecular aggregation. With this it is realized that with the increase of the abdominal perimeter, there is by itself an increase of fat around the heart. (Kim and al., 2021; Mahabadi et al., 2009)

There was also a positive correlation between the abdominal perimeter and pericardial and epicardial fat, found in several other studies. This correlation states that abdominal girth may be a predictive factor of increased fat around the heart. (Blinova Et al., 2019; Nu and al., 2021; Rabkin , 2014)

5.1 LIMITATIONS

This research presents as main limitation the lack of information about the clinical history, associated risk factors, medication taken by the participants and the non-differentiation by age groups, data that could impact on the results obtained.

6 FINAL CONSIDERATIONS

Individuals with an elevated abdominal girth have higher values of fat around the heart. Increased fat can play a leading role in the development of diastolic dysfunction and can lead to undesirable outcomes. The measurement of the abdominal perimeter can alert and anticipate eventual changes in diastole, and the transthoracic echocardiogram is the gold standard exam in this context.

REFERENCES

Andrade, K. A. P., & Rojas, M. A. P. (n.d.). Abdominal circumference cut-off. https://doi.org/10.5281/zenodo.6981770

Blinova, N. V., Azimova, M. O., Zhernakova, Y. V., Zheleznova, E. A., Yarovaya, E. B., Orlovskiy, A. A., Azimova, M. R., Dobrovolskaya, S. V., Ternovoy, S. K., & Chazova, I. E. (2019). Epicardial adipose tissue as a marker of visceral obesity and its association with metabolic parameters and remodeling of the left chambers of the heart in young people with abdominal obesity. Terapevticheskii Arkhiv, 91(9), 68–76. https://doi.org/10.26442/00403660.2019.09.000334

De Wit-Verheggen, V. H. W., Altintas, S., Spee, R. J. M., Mihl, C., Van Kuijk, S. M. J., Wildberger, J. E., Schrauwen-Hinderling, V. B., Kietselaer, B. L. J. H., & Van De Weijer, T. (2020). Pericardial fat and its influence on cardiac diastolic function. Cardiovascular Diabetology, 19(1). https://doi.org/10.1186/s12933-020-01097-2

DeFronzo, R. A., Ferrannini, E., Groop, L., Henry, R. R., Herman, W. H., Holst, J. J., Hu, F. B., Kahn, C. R., Raz, I., Shulman, G. I., Simonson, D. C., Testa, M. A., & Weiss, R. (2015). Type 2 diabetes mellitus. Nature Reviews Disease Primers, 1. https://doi.org/10.1038/nrdp.2015.19

Eroğlu, S. (2015). How do we measure epicardial adipose tissue thickness by transthoracic echocardiography? Anadolu Kardiyoloji Dergisi, 15(5), 416–419. https://doi.org/10.5152/akd.2015.5991

Fontes-Carvalho, R., Gonçalves, A., Severo, M., Lourenço, P., Rocha Gonçalves, F., Bettencourt, P., Leite-Moreira, A., & Azevedo, A. (2015). Direct, inflammation-mediated and blood-pressure-mediated effects of total and abdominal adiposity on diastolic function: EPIPorto study. International Journal of Cardiology, 191, 64–70. https://doi.org/10.1016/j.ijcard.2015.04.250

Hirata, Y., Yamada, H., & Sata, M. (2018). Epicardial fat and pericardial fat surrounding the heart have different characteristics. In Circulation Journal (Vol. 82, Issue 10, pp. 2475–2476). Japanese Circulation Society. https://doi.org/10.1253/circj.CJ-18-0923

Joseph, J. J., Deedwania, P., Acharya, T., Aguilar, D., Bhatt, D. L., Chyun, D. A., Di Palo, K. E., Golden, S. H., & Sperling, L. S. (2022). Comprehensive Management of Cardiovascular Risk Factors for Adults with Type 2 Diabetes: A Scientific Statement from the American Heart Association. In Circulation (Vol. 145, Issue 9, pp. 722–759). Lippincott Williams and Wilkins. https://doi.org/10.1161/CIR.0000000000001040

Kenchaiah, S., Ding, J., Carr, J. J., Allison, M. A., Budoff, M. J., Tracy, R. P., Burke, G. L., McClelland, R. L., Arai, A. E., & Bluemke, D. A. (2021). Pericardial Fat and the Risk of Heart Failure. Journal of the American College of Cardiology, 77(21), 2638–2652. https://doi.org/10.1016/j.jacc.2021.04.003

Kim, J. S., Kim, S. W., Lee, J. S., Lee, S. K., Abbott, R., Lee, K. Y., Lim, H. E., Sung, K. C., Cho, G. Y., Koh, K. K., Kim, S. H., Shin, C., & Kim, S. H. (2021). Association of pericardial adipose tissue with left ventricular structure and function: a region-specific effect? Cardiovascular Diabetology, 20(1). https://doi.org/10.1186/s12933-021-01219-4

Lang, R. M., Badano, L. P., Mor-Avi, V., Afilalo, J., Armstrong, A., Ernande, L., Flachskampf, F. A., Foster, E., Goldstein, S. A., Kuznetsova, T., Lancellotti, P., Muraru, D., Picard, M. H., Rietzschel, E. R., Rudski, L., Spencer, K. T., Tsang, W., & Voigt, J. U. (2015). Recommendations for cardiac chamber quantification

by echocardiography in adults: An update from the American society of echocardiography and the European association of cardiovascular imaging. European Heart Journal Cardiovascular Imaging, 16(3), 233–271. https://doi.org/10.1093/ehjci/jev014

Ma, W., Zhang, B., Yang, Y., Qi, L., Zhou, J., Li, M., Jia, J., Zhang, Y., & Yong, H. (2021). Association of epicardial fat thickness with left ventricular diastolic function parameters in a community population. BMC Cardiovascular Disorders, 21(1). https://doi.org/10.1186/s12872-021-02071-w

Mahabadi, A. A., Massaro, J. M., Rosito, G. A., Levy, D., Murabito, J. M., Wolf, P. A., O'Donnell, C. J., Fox, C. S., & Hoffmann, U. (2009). Association of pericardial fat, intrathoracic fat, and visceral abdominal fat with cardiovascular disease burden: The Framingham Heart Study. European Heart Journal, 30(7), 850–856. https://doi.org/10.1093/eurheartj/ehn573

Mitchell, C., Rahko, P. S., Blauwet, L. A., Canaday, B., Finstuen, J. A., Foster, M. C., Horton, K., Ogunyankin, K. O., Palma, R. A., & Velazquez, E. J. (2019). Guidelines for Performing a Comprehensive Transthoracic Echocardiographic Examination in Adults: Recommendations from the American Society of Echocardiography. Journal of the American Society of Echocardiography, 32(1), 1–64. https://doi.org/10.1016/j.echo.2018.06.004

Nagueh, S. F., Smiseth, O. A., Appleton, C. P., Byrd, B. F., Dokainish, H., Edvardsen, T., Flachskampf, F. A., Gillebert, T. C., Klein, A. L., Lancellotti, P., Marino, P., Oh, J. K., Popescu, B. A., & Waggoner, A. D. (2016). Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Journal of the American Society of Echocardiography, 29(4), 277–314. https://doi.org/10.1016/j.echo.2016.01.011

Ni, X., Jiao, L., Zhang, Y., Xu, J., Zhang, Y., Zhang, X., Du, Y., Sun, Z., & Wang, S. (2021). Correlation between the distribution of abdominal, pericardial and subcutaneous fat and muscle and age and gender in a middle-aged and elderly population. Diabetes, Metabolic Syndrome and Obesity, 14, 2201–2208. https://doi.org/10.2147/DMSO.S299171

Okura, K., Maeno, K., Okura, S., Takemori, H., Toya, D., Tanaka, N., & Miyayama, S. (2015). Pericardial fat volume is an independent risk factor for the severity of coronary artery disease in patients with preserved ejection fraction. Journal of Cardiology, 65(1), 37–41. https://doi.org/10.1016/j.jjcc.2014.03.015

Rabkin, S. W. (2014). The relationship between epicardial fat and indices of obesity and the metabolic syndrome: A systematic review and meta-analysis. In Metabolic Syndrome and Related Disorders (Vol. 12, Issue 1, pp. 31–42). https://doi.org/10.1089/met.2013.0107

Son, J. W., Sung, J. K., Lee, J. W., Youn, Y. J., Ahn, M. S., Ahn, S. G., Yoo, B. S., Lee, S. H., Yoon, J., Koh, S. B., & Kim, J. Y. (2016). Abdominal obesity and structure and function of the heart in healthy male Koreans the ARIRANG study. Medicine (United States), 95(39). https://doi.org/10.1097/MD.0000000000004930

Wharton, S., Lau, D. C. W., Vallis, M., Sharma, A. M., Biertho, L., Campbell-Scherer, D., Adamo, K., Alberga, A., Bell, R., Boulé, N., Boyling, E., Brown, J., Calam, B., Clarke, C., Crowshoe, L., Divalentino, D., Forhan, M., Freedhoff, Y., Gagner, M., … Wicklum, S. (2020). Obesity in adults: A clinical practice guideline. CMAJ, 192(31), E875–E891. https://doi.org/10.1503/cmaj.191707

World Health Organization. Regional Office for Europe. (n.d.). WHO European Regional Obesity : Report 2022.