

Development of a Dedicated Software for Sarcopenia Quantitative Analysis

Seung-Jin Kim¹, Chang-Won Jeong², Tae-Hoon Kim³, Hong Young Jun⁴, Kwon-Ha Yoon⁵

¹Department of Medical Science Wonkwang University, Iksan Jeonbuk South Korea, koch369369@wku.ac.kr

²Medical Convergence Research Center Wonkwang University, Iksan Jeonbuk South Korea, mediblue@wku.ac.kr

³Medical Convergence Research Center Wonkwang University, Iksan Jeonbuk South Korea,

tae_hoonkim@wku.ac.kr

⁴Medical Convergence Research Center Wonkwang University, Iksan Jeonbuk South Korea, zip80@wku.ac.kr

⁵Department of Radiology Wonkwang University School of Medical and Hospital, Iksan Jeonbuk South Korea, khy1646@wku.ac.kr(*corresponding author)

Article Info

Volume 81

Page Number: 2391 - 2397

Publication Issue:

November-December 2019

Article History

Article Received: 5 March 2019

Revised: 18 May 2019

Accepted: 24 September 2019

Publication: 12 December 2019

Abstract

This paper describes a dedicated analysis software for quantitative analysis of the sarcopenia disease. The proposed software extracts standardized results by specifying the same environment and imaging conditions based on medical images of the human L3 spinal segments in which various anatomic features can be observed. In particular, the results values of muscle, subcutaneous fat, and visceral fat, which are important factors for sarcopenia image analysis, are provided in various formats, such as DICOM, PNG, ROI, and CSV. In addition, all analyses are quickly and semi-automatically performed with great accuracy. The software supports the diagnosis and quantitative analysis of sarcopenia in the clinical practice, and it is expected that it can be applied to execute the analysis of sarcopenia disease in various diseases such as diabetes, obesity, cardiovascular disease etc.

Keywords: Analysis Software, L3, Medical Image, Quantitative Analysis, Sarcopenia.

1. INTRODUCTION

Skeletal muscles are located near the bones, through the whole body, and responsible to conduct the movement of the bones by applying forces, playing an important role in our daily lives [1]. The decrease in muscle mass due to aging and diseases, however, results in the appearance of other illness, including chronic renal failure, [2] osteoporosis, [3] complications and increased hospital stays [4]. This condition, called sarcopenia, [5], [6] is a disease [7] registered in the World Health Organization (WHO)'s classification system in 2016, responsible not only to increase the incidence of various diseases, but

also has a great impact on cancer patients [8], [9]. Although it is considered one of the most important issues, diagnostic criteria and quantitative measures of skeletal muscle mass have not yet been established to treat it.

The lack of clear diagnostic criteria for sarcopenia disease and the non-standardized imaging protocol are the main causes for the inaccuracy of the research process and analysis results.

This paper, therefore, proposes an analysis software specialized for sarcopenia to solve these problems based on medical images of the human's L3 spinal segment, [10] in which various

anatomic features can be observed. The main functions were designed to handle the images using Window & Leveling [11] technique and to specify the threshold, [12] through the binary coding method, to perform quantitative analysis under the same environment and conditions. At the same time, it is possible to quickly and accurately obtain standardized research results through the semi-auto image processing algorithm.

The organization of this paper is as follows. In section 2, the components of the proposed technology are described. In section 3, its processing and key functions are defined. In section 4, the acquisition of sarcopenia quantitative data, from medical images, is shown. In section 5 the results, conclusions and future research are discussed.

2. RELATED WORK

As research on the technique of analyzing medical images, such as computed tomography (CT) and magnetic resonance imaging (MRI), is globally active, the necessity of an analysis software, therefore, is increasing accordingly. Recently, artificial intelligence (AI) technologies are actively being introduced to develop automatic diagnosis assistance systems, such as detection, segmentation and quantification of lesions. Some examples of key software technologies involved are as follows.

2.2 ImageJ

ImageJ [13] is an open source platform, based on the JAVA programming language, developed by the National Institutes of Health (NIH). It is designed as an open architecture that provides scalability through JAVA's plug-in and Macro. Furthermore, It can display, edit, analyze, process, save, and print 8bit-color, grayscale, 16bit and 32bit images, and read many different image file formats, including TIFF, PNG, JPEG, and DICOM. It also supports various logical

operations between images as well as standardized image processing functions, such as window & leveling, threshold, smoothing, and convolution.

2.2 Rayplus

Rayplus [14] is a web-based platform that is remotely accessed by users to execute analysis. It can be easily used without installation process and it has image processing functions, such as crop, window & leveling, invert, zoom, rotate, and annotation to assist the user in analyzing medical images. 3D and AI technology are also applied, enabling clear and precise analysis.

The software presented in this paper is developed based on the improvement of ImageJ provided in the open source platform. In particular, images can be analyzed under the same environment and conditions as the real case and the analysis process can be simplified through semi-auto method to obtain standardized quantitative analysis results. For further research in the future, AI technology will be implemented to achieve automated analysis.

Capitalize only the first word in a paper title, except for proper nouns and element symbols. For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [8].

3. METHOD

3.1 Selection of regions for medical image analysis

This paper selected the human image L3 spinal segment (Lumbar Spine 3rd, L3), as shown in Figure 1, to perform the sarcopenia quantitative analysis. The L3 region includes the spine, internal organs, kidneys, and liver in addition to visceral fat, subcutaneous fat, and seven muscle groups (Psoas, Erector Spinae, Quadratus Lumborum, Transversus Abdominus, External, Internal Obliques, and Rectus Abdominus).

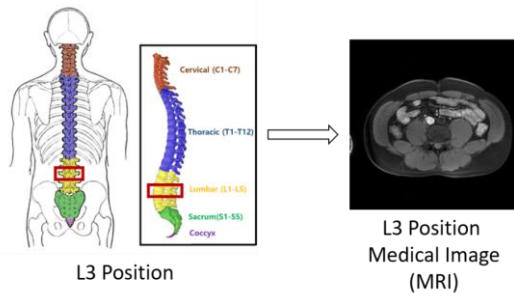


Figure 1: The medical images (MRI) of L3 spinal segment

These regions are key areas for observing a variety of anatomic features and are considered the most suitable areas for the quantitative analysis of the relationship between sarcopenia and various other diseases, such as aging, obesity, and osteoporosis.

3.2 Analysis software flow chart

Figure 2 indicates a flow chart of the overall qualitative and quantitative analysis process of the software. The analysis process is carried out semi-automatically and is divided into the following steps: execution, setting, confirm, and extraction.

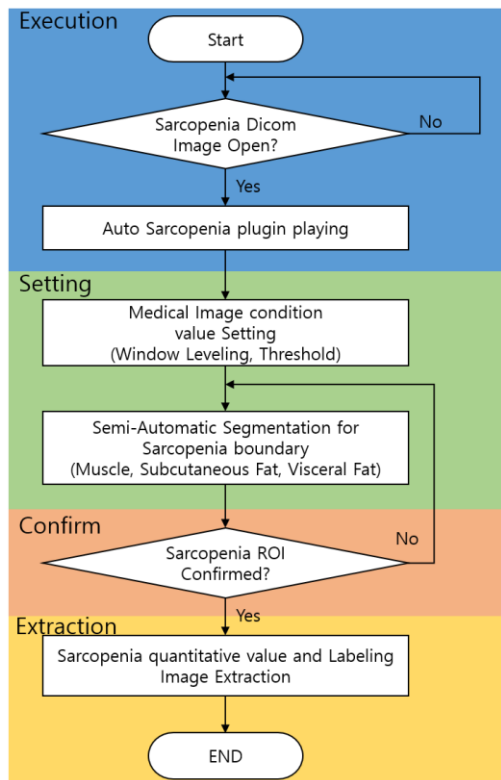


Figure 2: A flow chart of the sarcopenia analysis software execution

A. Execution

An analysis tool (sarcopenia plug-in) that reads the medical image data and processes significant features of sarcopenia is executed.

B. Setting

Window & leveling and threshold values of image data are specified and are applied to the entire image. The radiologist randomly classifies regions of significant factors of sarcopenia, thereby generating a region of interest (ROI).

C. Confirm

Determines the final ROI for each significant factor of sarcopenia by revising and verifying the work conducted by the radiologist in the previous step.

D. Extraction

Quantifies the results for each finalized ROI and images and employs them as analysis data.

3.3 Principles of running the sarcopenia analysis software execution

For the ROI that was randomly classified as significant factors of sarcopenia, when the button for each region had been selected in the sarcopenia analysis tool, window & leveling and threshold values were applied and the image processing algorithm, such as data preprocessing, ROI extraction, and analysis value measurement, was executed based on the transformed medical images to generate significant factors of sarcopenia ROI. All these processes are semi-automatically conducted by pressing the click button one time, as shown in Figure 3.

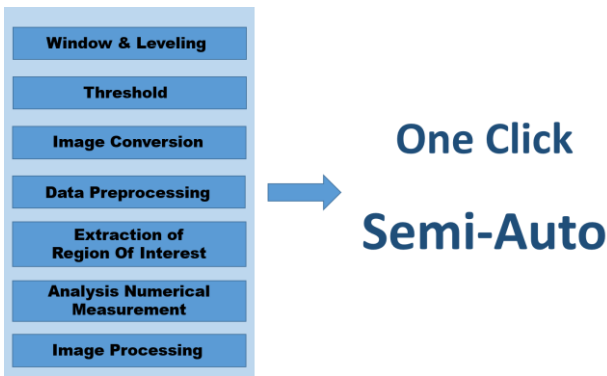


Figure 3: Analysis software's execution algorithm

3.4 Execution results

Figure 4 shows the final results of the extraction step in the analysis software's flow. The ROI generated through the previous verification step can be used to verify the analysis results for significant factors of sarcopenia. Moreover, PNG, ROI, and CSV files can be generated to observe the results.

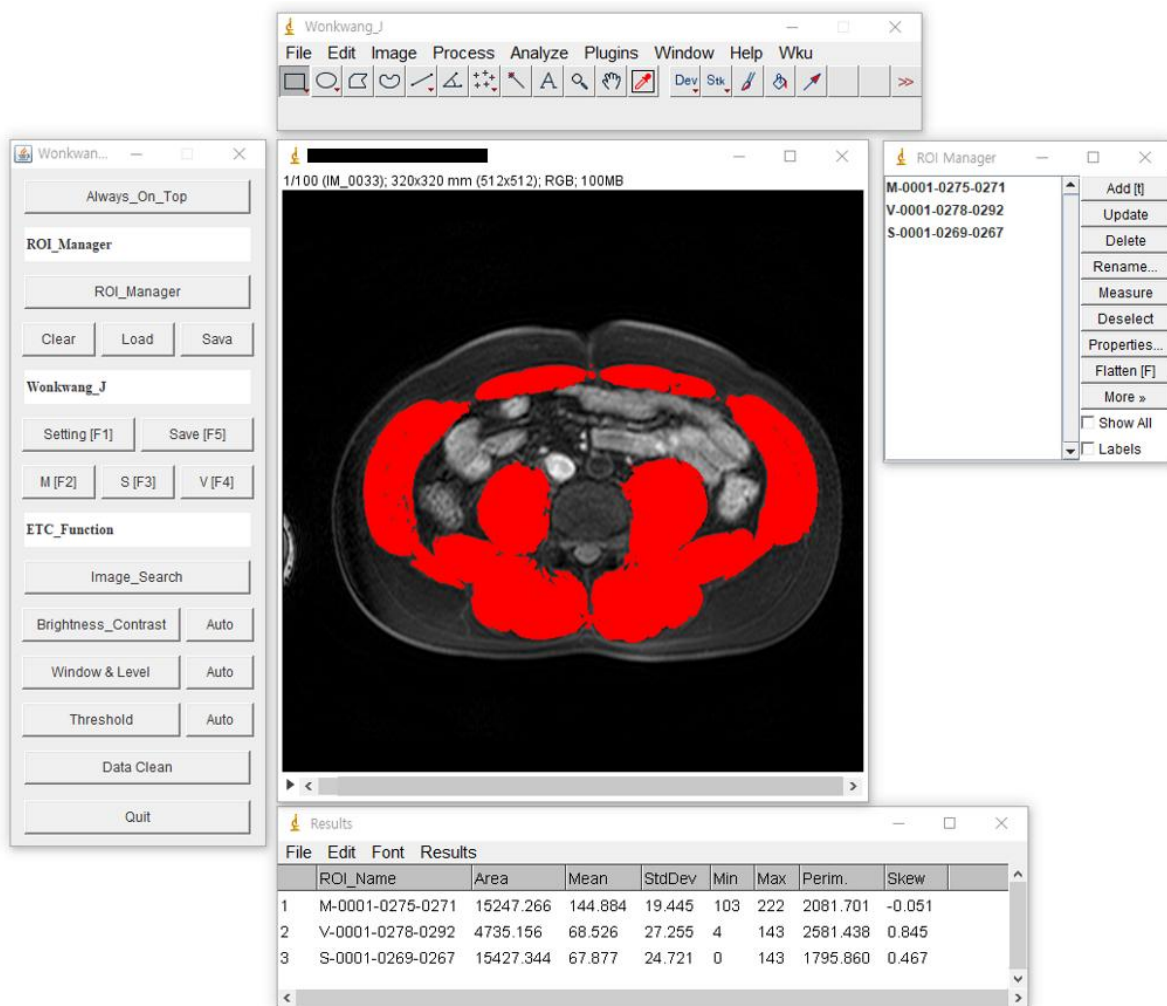


Figure 4: Results of analysis software extraction

4. RESULTS

The results of this study are presented in PNG files that display labeled images of muscles, subcutaneous fats, and visceral fats, where sarcopenia has more influence, ROI files, in which its coordinates are stored for each significant factor region, and CSV files that measure and

display quantitative data.

4.1 Labeled Image

Based on the medical images of the L3 segment, labeled images, extracted only from labeled regions, the overall labeled images integrating all regions for each muscle region, subcutaneous fats, and visceral fats. The significant factors of

sarcopenia are provided in PNG file format. Muscles, subcutaneous fats, and visceral fats are represented in red, blue, and yellow.

4.2 Region of Interest (ROI)

Boundary results are shown for the regions of significant factors of sarcopenia: muscle, subcutaneous fat, and visceral fat. The results are provided in the ROI file format and can be applied to medical images at any time.

4.3 Quantitative Numerical Data

Based on the generated ROI, quantitative data results of muscle, subcutaneous fat, and visceral fat regions corresponding to sarcopenia, are shown. The resulting variables, such as area, mean, standard deviation, threshold min & max, and perimeter, can be shown in a CSV file format [15-17].

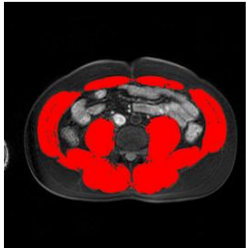
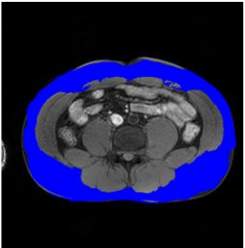
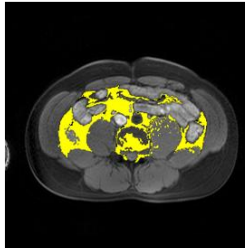
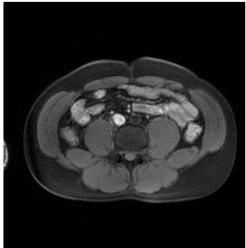
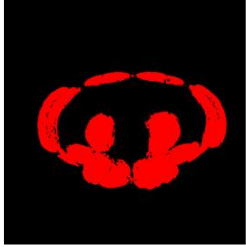
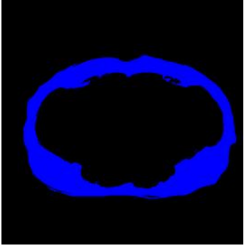

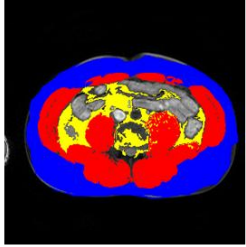
Muscle Labeling Image	Subcutaneous Fat Labeling Image	Visceral Fat Labeling Image	Original Image
			
Muscle Labeling Area	Subcutaneous Fat Labeling Area	Visceral Fat Labeling Area	Total Labeling Area
			

Figure 5: Labeled images results of significant factors of sarcopenia using the analysis software

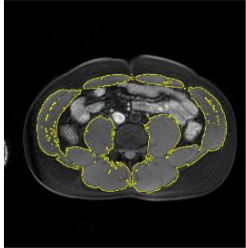
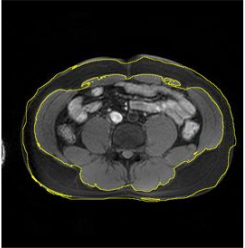
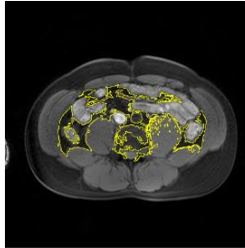
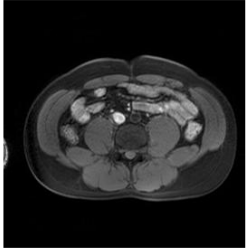
Muscle ROI	Subcutaneous Fat ROI	Visceral Fat ROI	Original Image
			

Figure 6: ROI results of significant factors of sarcopenia using the analysis software

	A	B	C	D	E	F	G	H	I
1		ROI_Name	Area	Mean	StdDev	Min	Max	Perim.	Skew
2	1	M-0001-0275-0271	15247.27	144.884	19.445	103	222	2081.701	-0.05
3	2	V-0001-0278-0292	4735.156	68.526	27.255	4	143	2581.438	0.845
4	3	S-0001-0269-0267	15427.34	67.877	24.721	0	143	1795.86	0.467

Figure 7: Quantitative numeric results of significant factors of sarcopenia using the analysis software

5. CONCLUSION AND FUTURE RESEARCH

In this paper, we developed and presented a software specialized in quantitative analysis of sarcopenia from medical images and based on the position of human L3 spinal segment. It is able to conduct analysis using a semi-auto method in each step, enabling the research results to be obtained promptly. In addition, by unifying the conditions for medical image analysis, the regions corresponding to muscle, subcutaneous fat, and visceral fat are measured in the same environment, and the image results after the labeling process are offered in a PNG file format, whereas the standardized quantitative numeric results are displayed in ROI and CSV. The analysis software will contribute to the sarcopenia study by executing quantitative analysis of the disease based on medical images. It also defines a starting point in electing a diagnostic criterion and a quantitative analysis method.

Furthermore, we plan to develop an integrated software platform for acquiring the analysis results using an automated method, rather than a semi-automatic technique, by inputting the labeled PNG file image obtained from the analysis software in an AI deep learning algorithm.

ACKNOWLEDGEMENT

This study was supported by the Korea Health Technology R&D Project through the Korea Health Industry Development Institute(KHIDI), funded by the Ministry of Health & Welfare(HI18C1216).

REFERENCES

1. W. R. Frontera and J. Ochala. **Skeletal muscle: a brief review of structure and function**, *Calcif Tissue Int*, vol. 96, no. 3, pp. 183-195, 2015.
doi: 10.1007/s00223-014-9915-y.
2. R. N. Moorthi and K. G. Avin. **Clinical relevance of sarcopenia in chronic kidney disease**, *Curr Opin Nephrol Hypertens*, vol. 26, no. 3, pp. 219-228, 2017.
doi: 10.1097/MNH.0000000000000318.
3. M. H. Edwards, et al. **Osteoporosis and sarcopenia in older age**, *Bone*, vol. 80, pp. 126-130, 2015.
doi: 10.1016/j.bone.2015.04.016.
4. J. DeAndrade, et al. **Sarcopenia is a risk factor for complications and an independent predictor of hospital length of stay in trauma patients**, *J Surg Res*, vol. 221, pp. 161-166, 2018.
doi: 10.1016/j.jamcollsurg.2016.06.342
5. R. D. Boutin, et al. **Sarcopenia: Current Concepts and Imaging Implications**, *AJR Am J Roentgenol*, vol. 205, no. 3, pp. 23, 2015
doi: 10.2214/AJR.15.14635.
6. A. J. Cruz-Jentoft, et al. **Sarcopenia: revised European consensus on definition and diagnosis**, *Age Ageing*, vol. 48, no. 1, pp. 16-31, 2019.
doi: 10.1093/ageing/afy169.
7. Sarcopenia Disease registered WHO, available at <https://www.icd10data.com/ICD10CM/Codes/M00-M99/M60-M63/M62-M62.84>

8. S. J. Lee, Y. J. Park, and K.B. Cartmell. **Sarcopenia in cancer survivors is associated with increased cardiovascular disease risk**, *Support Care Cancer*, vol. 26. No. 7, pp. 2313-2321, 2018.
doi: 10.1007/s00520-018-4083-7.
9. S. Morishita, **Prevalence of Sarcopenia in Cancer Patients: Review and Future Directions**, *International Journal of Physical Medicine & Rehabilitation*, vol. 4, no. 3, 2016.
doi: 10.4172/2329-9096.1000342
10. L. Hansen, et al. **Anatomy and biomechanics of the back muscles in the lumbar spine with reference to biomechanical modeling**, *Spine*, vol. 31, no. 17, pp. 1888-99, 1976.
11. ImageJ Software Window & Leveling Guide, available at
<https://imagej.nih.gov/ij/docs/guide/148-28.html;28.2.2>
12. ImageJ Software Threshold Guide, available at
<https://imagej.net/Thresholding>
13. ImageJ Software, available at
<http://imagej.nih.gov/ij/>
14. R. Yuan, et al. **RayPlus: a Web-Based Platform for Medical Image Processing**, *J Digit Imaging*, vol. 30, no. 2, pp. 197-203, 2017.
doi: 10.1007/s10278-016-9920-y.
15. Mullakhmetov, K.S., Sadriev, R.D., Akhmetshin, E.M. 2019. Influence of corporate culture on the system of management in modern conditions. *Entrepreneurship and Sustainability Issues*, 7(2), 1098-1113.
[http://doi.org/10.9770/jesi.2019.7.2\(22\)](http://doi.org/10.9770/jesi.2019.7.2(22))
16. Puryaev, A., Puryaev, A.A. 2019. Mathematical tooling of accounting non-economic characteristics during the assessing process of investment project effectiveness. *Entrepreneurship and Sustainability Issues*, 7(2), 1114-1135.
[http://doi.org/10.9770/jesi.2019.7.2\(23\)](http://doi.org/10.9770/jesi.2019.7.2(23))
17. Yu, D., Ebadi, A.G., Jermstiparsert, K., Jabarullah, N., Vasiljeva, M.V., & Nojavan, S. (2019) Risk-constrained Stochastic Optimization of a Concentrating Solar Power Plant, *IEEE Transactions on Sustainable Energy*, <https://doi.org/10.1109/TSTE.2019.2927735>.