International Journal of Mechanical Engineering and Technology (IJMET)
Volume 9, Issue 6, June 2018, pp. 1174–1179, Article ID: IJMET_09_06_129
Available online at http://www.iaeme.com/ijmet/issues.asp?JType=IJMET&VType=9&IType=6
ISSN Print: 0976-6340 and ISSN Online: 0976-6359

PILOT TEST TO BUILD BACK-PAIN DIAGNOSIS SUPPORT SYSTEM

Seung-Nam Min
Shinsung University, Drone & Industrial Safety Engineering, 1, Daehak-ro, Dangjin-si 31801, Republic of Korea

Dong-Joon Kim
Hanyang University, Industrial and Management Engineering,
55 Hanyangdaehak-ro. Ansan-si 15588, Republic of Korea
Corresponding Author

Murali Subramaniyam
Department of Mechanical Engineering,
SRM Institute of Science and Technology, Kattankulathur, India
Corresponding Author

ABSTRACT

The purpose of this study was to build a methodology to support the diagnosis of back pain. This study used easy posture and frequency analysis of EMG for non-MVC normalizing to focus on avoiding damage to back-pain patients during the test. Participants were asked to perform a simple walking task. Measured muscles were biceps femoris (BF) muscle, lateral gastrocnemius (LG) muscle. In the BF muscle, the mean of healthy persons was 46.28 (±8.66), the mean of back pain patients was 26.11 (±10.69). In the LG muscle, the mean of healthy persons was 58.36 (±15.69), and the mean of back pain patients was 20.97 (±10.78). In both t-test results of muscles showed significant differences. It is considered to be a compensation mechanism transferring the body weight to lower body related to muscle weakness. Also, this study can support back-pain diagnosis through a stochastic approach using Bayes theorem.

Key words: EMG, Low-Back Pain, Probabilistic Approach, Bayes' Theorem.

Cite this Article: Seung-Nam Min, Dong-Joon Kim and Murali Subramaniyam, Pilot Test To Build Back-Pain Diagnosis Support System, International Journal of Mechanical Engineering and Technology, 9(6), 2018, pp. 1174–1179.
http://www.iaeme.com/ijmet/issues.asp?JType=IJMET&VType=9&IType=6

1. INTRODUCTION

The final goal of this study is to construct a methodology to support back pain discrimination using electromyography to support physician's discrimination before testing such as X-ray or expensive MRI. An additional goal is to minimize the load on the low back pain patient during the test.

Back pain is a major cause of disability and economic costs, and equipment such as MRI has been developed to reduce this economic loss. Currently, the most accurate anatomic test for diagnosis of back pain is magnetic resonance imaging (MRI). The researchers considered MRI to be a miracle-like technology and used it extensively to detect and treat the anatomical and structural problems of the spine. However, this diagnostic technique is costly, and it is difficult to diagnose the lumbar spine because abnormal discs are often found in healthy individuals when lumbar MRI is performed. Boos et al. [1] reported that 96% of patients showed disk escape, and 35% of patients showed disk rupture in patients who showed disk. On the other hand, in the control group, which had no symptoms at all, 76% of the patients reported disk escape and 13% of the patients had disk rupture. According to Jarvik et al. [2], MRI findings, clinical findings and treatment results of nonspecific low back pain patients did not show significant response. Pain, not a skeletal problem such as posterior spinal pain and sacroiliac arthralgia, is difficult to diagnose using imaging diagnostics. It is useless to perform imaging diagnosis of MRI, CT, etc. in patients who are not clinically verified. Therefore, there is a need for a clinical diagnostic methodology that assists discrimination of low back pain through a simple measurement protocol and can determine the necessity of imaging test.

In this study, we focused on minimizing the pain during the examination of patients with back pain. Generally, patients are required MVC (maximum voluntary contraction) to obtain an independent EMG signal. However, patients often fail to perform MVC or feel pain and cannot secure credibility. Therefore, we decided to use a measurement method that requires a minimum posture such as sitting or standing in a chair regardless of the degree of pain or an average in a sitting posture and a comfortable sitting posture. McGill [3] and O'Sullivan et al. [4] reported that the SVIC (submaximal voluntary isometric contraction) is more reliable in the pain population, and According to O'Sullivan et al. [4], Allison et al. [5], Snijders et al. [6], SVIC is more sensitive when evaluating low-level muscle activity, so it was considered appropriate for electromyography in low back pain patients.

In this study, it is expected that the painless diagnosis methodology will be embodied in the patients with low back pain, and it will minimize the errors by identifying the patients with low back pain and judging the necessity of expensive MRI or CT in the future. It will also provide clinicians with a reliable basis for rational diagnosis.

1.1. Normalization of Muscle Activity

In Dankaerts' study [7], the general sitting posture was set as Sub-MVIC (maximal voluntary isometric contraction), and the difference in sitting position was evaluated using this. Van Damme et al. [8] also reported that sub-MVIC was used and that quasi-maximal contraction is more appropriate for EMG normalization in pain group and more sensitive when evaluating low-level muscle activity. Also, this study shows no significant difference in MVC between the CLBP patient group and the control group. As a result, it can be seen that there is no difference in MVC between the back pain patient and the control group, and it is difficult to discriminate the back pain through muscle strength itself. Also, in studies involving patients with low back pain, MVC measurement for muscle activity normalization should be avoided, considering that the participant is vulnerable to pain.

1.2. Selection of Measuring Muscles

Penney et al. [9] compared the differences between low back pain patients and controls in the SLS (single leg stance) test. The measurement muscles were femoral and gluteal muscles and found that the patients had weakened gluteus than the control group with the same age and sex.

Also, patients with low back pain used more femoral muscle when using one leg, which is presumed to be a compensation mechanism associated with weakness.

The results of the present study suggest that the muscle use pattern of back pain patients is different and that other muscles are used mainly to avoid the use of the affected muscle rather than the back muscle itself which directly affects the pain. We know that the function of body weight support, which is the main function of the waist, is transferred to the lower body. Therefore, in this study, it is considered that the focus should be on the muscles of the lower body rather than the muscles of the waist itself.

1.3. Probabilistic Approach for Diagnosis

In this study, the Bayesian theorem is used to calculate the probability of belonging to each group (healthy, patient) based on the range of data when new measured data is input by using parameter value. In the probabilistic approach using Bayes' theorem, we set the prior probability for each group to 0.5.

2. METHODS

In this study, a pilot test was performed on five healthy subjects and five patients with low back pain. Measurement posture was set as a simple walking gesture; measurement muscle was biceps femoral muscles, lateral gastrocnemius muscles. The left and right muscles were measured at the same time to reflect the characteristics of both muscles. The EMG data were analyzed by separating relative power (band1: 5-64Hz, band2: 64-128Hz, band3: 128-256Hz, band4: 256-512Hz, band5: 512-1024Hz) after frequency analysis. The final parameters used in the study were set to the ratio of the 5th band to the 4th band (Fig. 1).

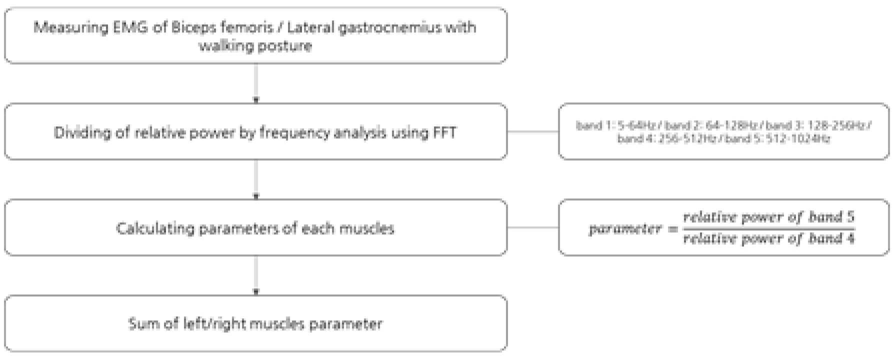

Figure 1 Flowchart of data analysis

3. RESULTS

3.1. Results of Frequency Analysis

The mean and standard deviation of the parameters for each muscle is shown in Table 1. In the biceps femoris muscle, the mean was 46.28 (±8.66) in healthy subjects and 26.11 (±10.69) in the patient group. In the case of the lateral gastrocnemius muscle, the mean was 58.36 (±15.69) and 20.91 (±10.78) for healthy subjects and patient group, respectively. The t-test analysis showed a significant difference (p<0.05).

Table 1 The mean and standard deviation of the parameters for each muscle

Muscles	Subject	Mean	SD	Result of t-test
Biceps femoris muscle	Healthy	46.28	8.66	*p*<0.05
	Patient	26.11	10.69	
Lateral gastrocnemius muscle	Healthy	58.36	15.69	*p*<0.05
	Patient	20.91	10.78	

Based on the mean and standard deviation results, the probability distribution of parameters values for each muscle and group shown in Fig. 2.

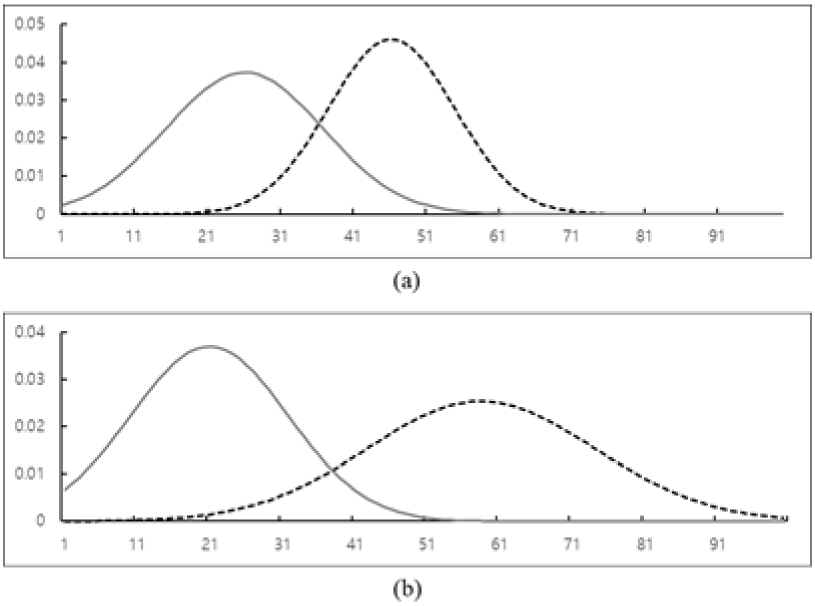

Figure 2 The probability distribution of parameter of biceps femoris muscle and lateral gastrocnemius muscle (a: the distribution biceps femoris muscle in healthy person (dotted line) and patient with low back pain (continuous line), b: the distribution lateral gastrocnemius muscle in healthy person (dotted line) and patient with low back pain (continuous line))

3.2. Results of Probabilistic Approach

In this study, we use a probabilistic approach to determine whether a patient has low back pain. For this purpose, it is assumed that new data of the subject is measured. The range of new data calculated by measuring EMG signals for biceps femoris muscles and lateral gastrocnemius muscles is each 49.17-55.25 and 54.23-59.92 through 3 times measurement (Table 2).

Table 2 The example data of new subject for diagnosis method

Muscles	1^{st}	2^{nd}	3^{rd}	Range of data
Biceps femoris muscle	50.70	55.25	49.17	49.17-55.25
Lateral gastrocnemius muscle	59.92	54.23	57.16	54.23-59.92

The range of this example data can be displayed on the probability distribution shown in Fig. 2, as shown in Fig. 3.

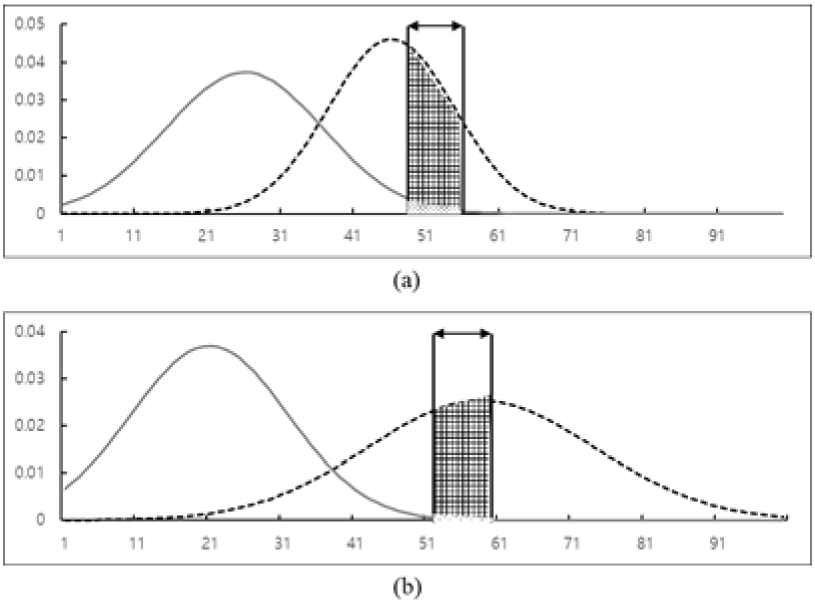

Figure 3 The range of example data displayed on the probability distribution (a: biceps femoris muscle, b: lateral gastrocnemius muscle, hatched area means the probability of a healthy group, a region of dotted area implies probability of a patient group)

Hatched areas either lines/dots indicate the probability of groups. In case of biceps femoris muscle, the combined value for the healthy group was 0.255, and the combined value for the low back pain patient was 0.015. The probability of being included in the healthy group is 94.4%, and the probability of being included in the low back pain group is 5.6%.

In case of the lateral gastrocnemius muscle, the combined value for the healthy group was 0.176, and the combined value for the low back pain patient was 0.001. The probability of being included in the healthy group is 99.4%, and the probability of being included in the low back pain group is 0.6%. As described above, if the data distribution is measured, it is possible to determine probabilistically whether the subject has back pain when new data is input.

4. CONCLUSIONS

In this study, two muscles related to body support at standing were measured, and only a pilot test was performed to verify the set hypothesis. In future studies, we will increase the number of participants, measuring muscles, postures to increase the separation power of the model.

The prior probability is also an important factor in Bayes' theorem. The prior probability means the probability that the measurement data can exist in the group by the preliminary information. If the measurement data is assigned to the back pain discrimination, the physical activity level and the occupation type of the measurement subject can be influenced. In this regard, Penney et al. (2014), there was no significant difference in age, sex, weight, and height between the low back pain patient group and the control group. But there was a difference between the subjective Oswestry Back Disability Index and physical activity level. In this way, since there is a variation in each individual, it is necessary to apply a model that can reflect this to the probabilistic approach.

In future studies, we will add electrocardiogram to quantitatively reflect the degree of subjective pain and the degree of difficulty experienced by individuals when taking a specific action or posture. Also, we consider the type of occupation that can induce back pain; we will continue to analyze to increase discrimination power.

ACKNOWLEDGEMENT

This work is supported by the National Research Foundation of South Korea, Project No: NRF-2017R1D1A3B03034037.

REFERENCES

[1] Boos, N., Rieder, R., Schade, V., Spratt, K.F., Semmer, N., Aebi, M. The diagnostic accuracy of magnetic resonance imaging, work perception, and psychosocial factors in identifying symptomatic disc herniations. *Spine*. **20**(24), 1995, pp. 2613-2625.

[2] Jarvik, J.G., Hollingworth, W., Martin, B., Emerson, S.S., Gray, D.T., Overman, S., Kreuter, W. Rapid magnetic resonance imaging vs radiographs for patients with low back pain: a randomized controlled trial. *Jama*. **289**(21), 2003, pp. 2810-2818.

[3] McGill, S.M. Electromyographic activity of the abdominal and low back musculature during the generation of isometric and dynamic axial trunk torque: implications for lumbar mechanics. *J. Orthop. Res.* **9**(1), 1991, pp. 91-103.

[4] O'sullivan, P.B., Grahamslaw, K.M., Kendell, M., Lapenskie, S.C., Möller, N.E., Richards, K.V. The effect of different standing and sitting postures on trunk muscle activity in a pain-free population. *Spine*. **27**(11), 2002, pp. 1238-1244.

[5] Allison, G.T., Godfrey, P., Robinson, G. EMG signal amplitude assessment during abdominal bracing and hollowing. *J. Electromyogr. Kinesiol*. **8**(1), 1998, pp. 51-57.

[6] Snijders, C.J., Bakker, M.P., Vleeming, A., Stoeckart, R., Stam, H.J. Oblique abdominal muscle activity in standing and in sitting on hard and soft seats. *Clin. Biomech*. **10**(2), 1995, pp. 73-78.

[7] Dankaerts, W., O'sullivan, P., Burnett, A., Straker, L. Altered patterns of superficial trunk muscle activation during sitting in nonspecific chronic low back pain patients: importance of subclassification. *Spine*. **31**(17), 2006, pp. 2017-2023.

[8] Van Damme, B., Stevens, V., Van Tiggelen, D., Perneel, C., Crombez, G., Danneels, L. Performance based on sEMG activity is related to psychosocial components: differences between back and abdominal endurance tests. *J. Electromyogr. Kinesiol*. **24**(5), 2014, pp. 636—644.

[9] Penney, T., Ploughman, M., Austin, M.W., Behm, D.G., Byrne, J.M. Determining the activation of gluteus medius and the validity of the single leg stance test in chronic, nonspecific low back pain. *Arch. Phys. Med. Rehabil.* **95**(10), 2014, pp. 1969-1976.