Development of Smartphone Application for Calculating the Low Back Pain Risk

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Abstract

This study primarily relies on a smartphone application, developed within our research institute known as Yo-bukun, for the real-time estimation of lumbar burden. The Yo-bukun is capable of estimating the lumbar burden of a subject (the user) by placing an app. installed smartphone in the subject's chest pocket, while the subject is lifting/ relocating an object. The subject's movements are assessed through sensors embedded in the smartphone and certain aspects of their physical information initially fed into the app. are used in the estimation formula for determining lumbar burden. In the current scenario, Yo-bukun lacks the capability to ascertain whether the user is holding an object or not; consequently, it can only estimate the lumbar burden for limited cases of a subject holding an object. To address such limitations, the proposed system integrates voice recognition to facilitate lumbar burden estimation, considering the presence or absence of an object. Further, it was incorporated with the capability to recalculate lumbar burden after measurements, enabling prospective studies.

Keywords: Lumbar burden estimation, smartphone application, voice recognition.

1. Introduction

The smartphone application called Yo-bukun allows you to estimate the lumbar burden when holding an object in real time by placing a smartphone in the chest pocket [1], [2]. The estimation method of the Yo-bukun involves utilizing smartphone sensors such as the acceleration sensor and gyro sensor to assess the user's state (standing, sitting, turning, crouching, walking). Subsequently, the user's physical information is incorporated, and the estimation formula used in MIYADAI Pro developed by Professor Mitarai [3] is applied to perform the estimation. Here, the user needs to set the user's physical information and the weight of the object being held by the user before taking measurements. During measurement, the lumbar burden is estimated at every second in real-time.

However, few constraints have been identified in its functionality. The initial challenge is the inability to determine whether the user is actively holding an object during measurement or not. Therefore, throughout the measurement the lumbar burden is approximated under the assumption that the user is consistently holding an object. As a result, the Yo-bukun can't estimate the lumbar burden regarding movements occurring before the user holds an object or after putting an object down. The second issue arises upon the completion of measurement, in which the user has not been given the capability to modify the set information and reevaluate the lumbar burden. In that case, if a measurement has already been conducted with incorrect information, it demands repeating the same measurement. Therefore, this paper outlines the functionalities introduced to address and resolve these identified challenges.

2. Methodology

This paper describes the proposed method that can be resolved only using a smartphone, emphasizing user-friendly ease of operation.

2.1. First problem-solving method

To address the problem of measurement being possible only in the limited situation where the user holds an object, a voice recognition function has been introduced to the Yo-bukun. The user articulates speech, while initially holding an object and when releasing it, and this voice information is utilized to determine the object possession status. The judgment method can be described as follows: upon detecting the initiation of object holding, the system assumes continuous possession until the moment of object release is identified. Conversely, if the system detects the timing when the user puts down an object, it assumes that the user does not hold an object until the point of object holding initiation is recognized. In this way, the status of object possession can be determined using voice recognition.

2.2. Second problem-solving method

The limitation was explained wherein, the post-measurement, user is unable to modify pre-measurement information and recalculate lumbar burden again. Utilizing the estimation formula utilized in Yo-bukun, the key parameters for lumbar burden estimation, extending beyond the pre-measurement information provided by the user were identified. These additional parameters are recorded for each lumbar burden estimation. Consequently, even if the user modifies the pre-measurement information after the completion of measurement, the proposed system facilitates the use of recorded parameter data for any recalculations of lumbar burden.

3. Implementation Procedure

3.1. First problem-solving Procedure

With the use of Apple's speech recognition framework [4], a voice recognition feature was incorporated with the Yo-bukun and developed a system that assesses the lumbar burden based on the user's object possession status. This advancement enables the estimation of lumbar burden solely through a smartphone, considering the user's object possession status. The proposed system estimates lumbar burden based on a user-selected preset weight if an object is held. In instances where the user is not holding an object, the system assumes an object weight of 0 kg. Furthermore, this approach replaces traditional button operations as the commencement (Start) and cessation (End) of measurement have been automated through voice recognition.

3.2. Second problem-solving Procedure

A review was conducted on the fundamental parameters crucial for lumbar burden estimation and the system development was carried forward for their systematic recording during measurements. Moreover, the system was facilitated with the use of recorded parameters to reassess lumbar burden subsequent to the measurement. As a result, users possess the capability to modify pre-measurement information, enabling recalculation of lumbar burden based on these alterations.

4. Experiment

Two experiments were conducted to validate the functionality of the introduced system.

4.1. First experiment

In the first experiment, Yo-bukun was employed for lumbar burden assessment, using specific verbal cues during both the Start and End of the object handling process. The weight of the object was set at 2 kg. To ensure the optimal accuracy in estimation result, the smartphone was securely affixed to a vest, positioned in close proximity to chest area. Initially, the configuration was set for the subject to commence the measurement without holding an object as the Yo-bukun also offers configurability to specify the status of holding an object or not, at the initialization. The Fig. 1 depicts the following operational sequence proceeded during the experiment:

a) Start the measurement without any object.
b) Uttered a specific word and lifted an object after 11 seconds.
c) Raised the upper half of the body.
d) Safely place the object on the floor by uttering a word after 21 seconds.
e) End the measurement by raising the upper half of the body.

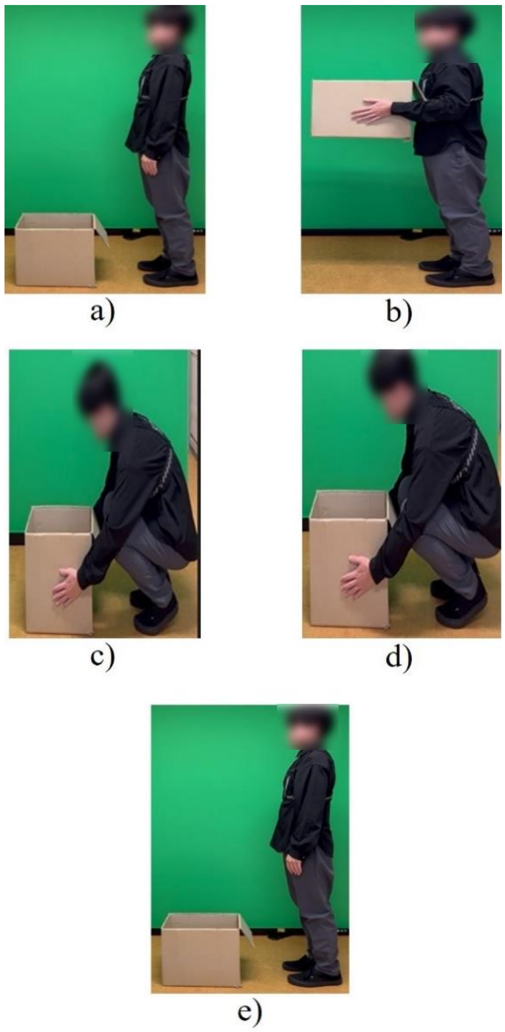

Fig. 1. Operation sequence of the first experiment

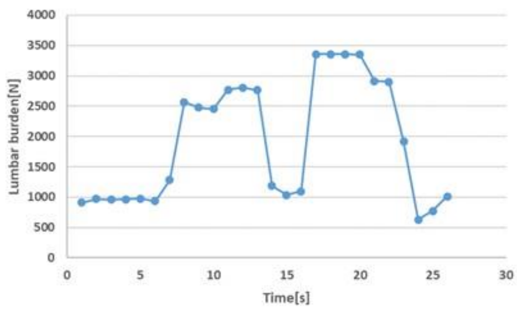

Fig. 2. Graph illustrating lumbar burden estimation during the first experiment.

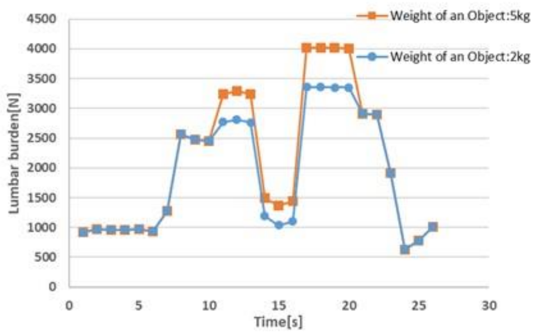

Fig. 3. Graph showing the change in lumbar burden estimation during the second experiment; graph for the object weight 2kg (blue), 5kg object (orange)

4.2. Second experiment

The second experiment was conducted to reassess the estimation results obtained from the initial trial by modifying user-input information. In this subsequent trial, an examination was made to determine the impact on estimation results by altering the weight of an object to 5 kg.

5. Experiment result

5.1. First experiment result

The experimental results are illustrated in Fig. 2. The first experiment result outlines the procedure for determining whether the presence or absence of an object can be considered. During the measurement, the Yo-bukun is modified to enable the recording of user-predefined information and the other parameters essential for estimating lumbar burden. Consequently, the recorded parameters included the weight of an object, with the weight being logged every second. From this, it is evident that the Yo-bukun assesses lumbar burden based on the criteria that a weight of 0 kg indicates the person is not holding an object, whereas a weight of 2 kg implies the person is holding an object. The first experiment result revealed that the weight was 0 kg for the initial 10 seconds, 2 kg from seconds 11 to 20 Sec., and returned to 0 kg thereafter until the end of the measurement. Therefore, it was deduced that lumbar burden could be estimated through voice recognition, considering the presence or absence of an object.

5.2. Second experiment result

The reevaluated results, depicting changes on object weight from 2 kg to 5 kg, are illustrated in Fig. 3. During different measurements when no object is held, the recorded weight is maintained at 0 kg, yielding consistent measurements. Subsequently, the object's weight is adjusted to 5 kg, and recalculation is executed during object holding. As a result, no variations were observed during the intervals from 0 to 11 seconds and from 21 Seconds until the conclusion of the measurement when the person was not holding an object. The fluctuations in results were only evident from the 12 to 20 seconds time interval when the person was holding an object. Therefore, the results of the second experiment illustrate the possibility of parameter adjustments and post-measurement recalculations.

6. Conclusion

Through the integration of voice recognition into Yo-bukun, the system is now capable of estimating lumbar burden, considering whether the user is holding an object or not. The start and end of measurements which were previously reliant on manual button press within the application, can now be automated via voice recognition. By recording the parameters essential for lumbar burden estimation during the measurement, users have the flexibility to modify pre-set information even after completing the measurement, allowing the re-calculation of lumbar burden. The implementation of this system has also simplified the prospective studies of how changes in object weight or physical information during the same movement influence lumbar burden.

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Authors Introduction

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Seigo Imura born in 2001. He is currently studying in department of environmental robotics, and will receive the B.Eng from University of Miyazaki in 2024.

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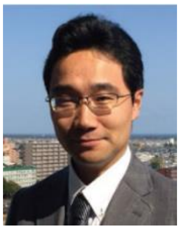

He received the B.E. and M.E. degree from Miyazaki University in 1998 and 2000, respectively. From 2000 to 2001, he was an Engineer in Asahi Kasei Corporation, Japan. In 2001, he joined Toyama University, Toyama, Japan, where he was a Technical Official in the Department of Intellectual Information Systems. In 2006, he joined Miyazaki University, Miyazaki, Japan, where he was an Assistant Professor in the Department of Electrical and Electronic Engineering. Since 2015, he is currently a Professor in the Department of Environmental Robotics. His main research interests are Neural Networks and Optimization Problems. In recent years, he has had interest in Biomedical Signal Processing using Soft Computing.