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Development of an Estimation Formula for Back Extensor Muscle Strength in patients with Postmenopausal Osteoporosis

Byung Hoon Lee[1], Eun Lee Lee[2], Yun Kyung Jeon[3], Mi Jin Kim[3], Dong Jun Park[4], Myung Jun Shin[5*]

[1]Department of Rehabilitation Medicine, Biomedical Research Institute, Pusan National University Hospita
[2]Department of Convergence Medical Institute of Technology, Pusan National University Hospital
[3]Division of Endocrinology, Department of Internal Medicine, Biomedical Research Institute, Pusan National University Hospital, Pusan National University School of Medicine
[4]Department of Healthcare Device Manufacturing, Sante Healthcare, Busan, Republic of Korea
[5]Department of Rehabilitation Medicine, Biomedical Research Institute, Pusan National University Hospital, Pusan National University School of Medicine

Introduction

The pain and skeletal deformity associated with osteoporosis may secondarily reduce muscle strength, and this has been established through previous studies to be closely correlated with back extensor strength. In this study, we compared BES estimated using Electromyography (EMG) and inertial measurement units (IMU) sensors with BES measured by the hand-held dynamometer (HHD) and developed a more convenient method for measuring BES and confirmed its validity. Initially developed through clinical trials on healthy women, our lumbar paraspinal strength estimation formula was subsequently refined through empirical testing on osteoporosis patients.

Methods

This study centers on postmenopausal women afflicted with osteoporosis (N=48) (table 1). Back extensor strength (BES) was assessed using Handheld Dynamometry (HHD) affixed with a Tripod & Belt system device in the prone position, with subjects exerting maximal effort to lift the upper body. Additionally, BES evaluations using EMG and IMU sensors were conducted during a single set of back extension exercises. EMG sensors were positioned at the L1 level, while IMU sensors were affixed to the interscapular area. Exercises comprised lifting the upper body from prone, sustaining for 5 seconds, resting for 10 seconds, repeated for 10 repetitions.

Results

Baseline characteristics were depicted in Table 1. An estimation equation for BES was derived via multiple linear regression analysis. A novel system was devised to predict BES, as measured by HHD, utilizing EMG and IMU signals acquired during back extension exercises (Figure 1). Quantitative parameters were extracted from EMG and IMU data. Notably, these parameters demonstrated disparities compared to those osteoporosis of healthy controls in a prior study. Three distinct models were constructed, incorporating muscle strength relative to BMI, weight, and height2 (figure 2). It was ascertained that the estimated BES index effectively approximated HHD-measured BES. Among the three indices, muscle strength/height2 exhibited the strongest correlation with measured values (r=0.743, p<0.001).

Table 1. Participants Characteristics

	Participants
Age (y)	69.13 ± 7.68
Height (cm)	154.61 ± 5.64
Weight (kg)	54.86 ± 7.24
BMI (kg/㎡)	22.98 ± 3.03
HHD_max (N)	83.42 ± 34.73
HHD_mean (N)	75.91 ± 21.64
Right HGS (kg)	22.69 ± 4.58
Left HGS (kg)	21.32 ± 4.34
FTSST (s)	8.87 ± 2.13
30s SST	18.85 ± 5.07
SMI	6.72 ± 0.78

Mean ± SD, HHD: Hand-held dynamometer; RMS: root mean square, muscle activity of the back extensor; Rt: right; Lt: left; HGS: Handgrip strength; FTSST: Five-times sit-to-stand test; 30s SST: 30secs sit-to-stand test; SMI: skeletal muscle index.

Fig 1. BES test using EMG and IMU sensor

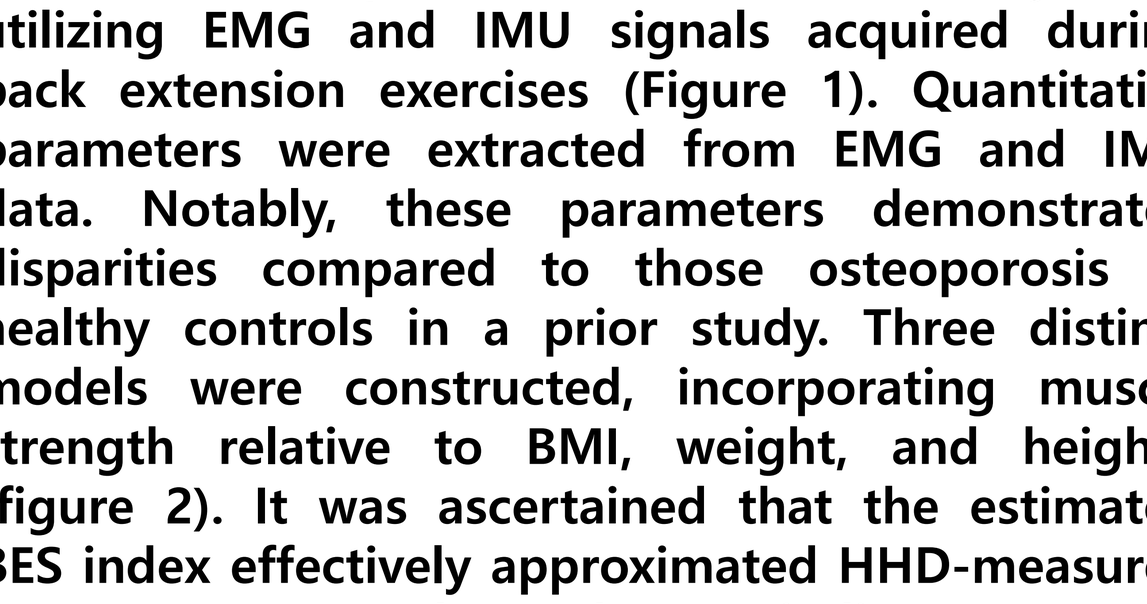
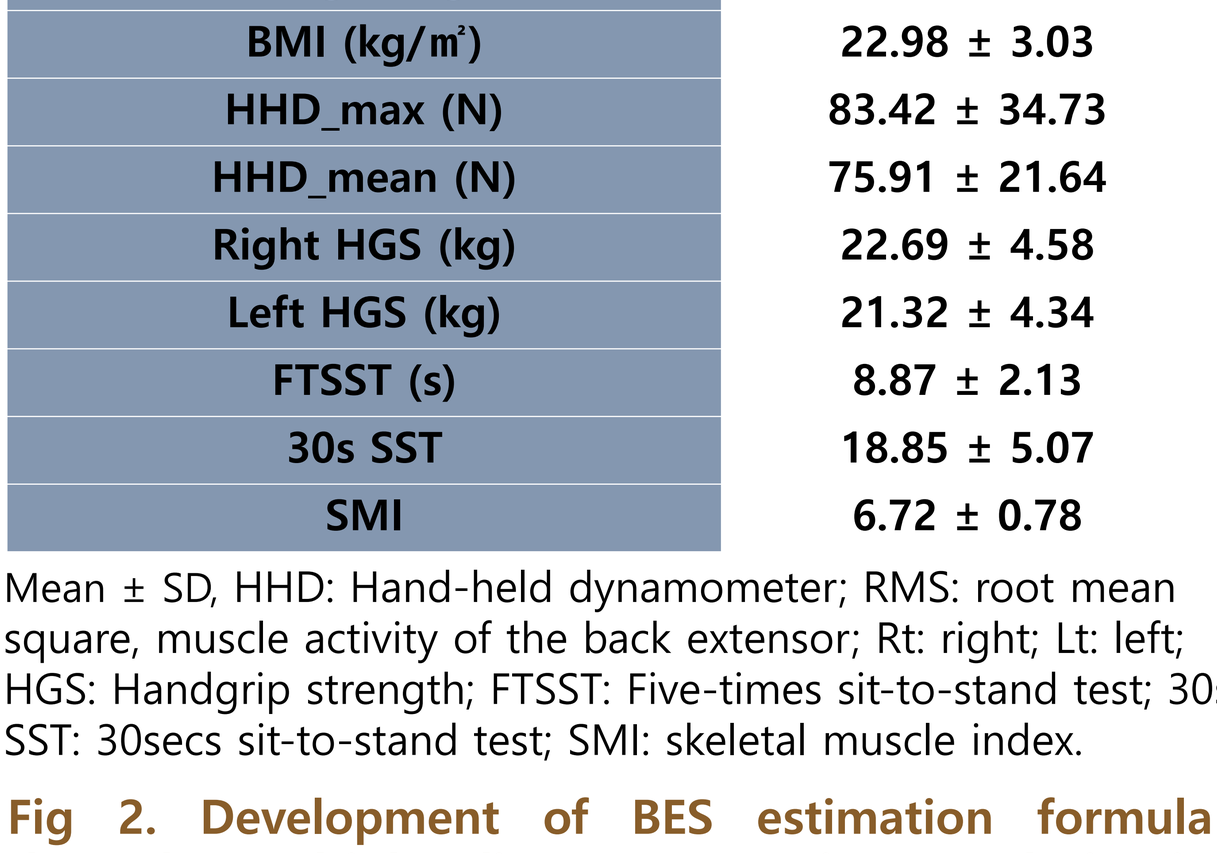


Fig 2. Development of BES estimation formula through multiple linear regression analysis in osteoporosis



Conclusion

A new method has been developed to measure the strength of the back extensor muscles, and it has been confirmed to be applicable to postmenopausal women with osteoporosis. Since a method for measuring back extensor strength in healthy young adults has already been developed in previous study, further research is needed to determine whether the back extensor measurement method can be used in screening for normal, osteopenic, and osteoporotic conditions.

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