Association between abdominal trunk muscle weakness and future osteoporotic vertebral fracture in middle-aged and older adult women: A three-year prospective longitudinal cohort study

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INTRODUCTION:

Osteoporotic vertebral fracture (OVF) is the most common type of fracture in older adults. Fracture prevalence and incidence increase with age, low bone mineral density (BMD), presence of old OVF is predictive of OVF. However, the events and circumstances leading to OVF are still unclear. Neuromuscular changes with aging are well-documented. It seems plausible that neuromuscular function of the trunk muscles could play an important role in the etiology. We developed an innovative exercise device for the abdominal trunk muscles that also measures muscle strength (Figure 1). This device enables subjects to perform strength measurement or strengthening exercises involving abdominal trunk muscles while in a sitting position without movement of the trunk or load on the spine. Our previous study demonstrated that the strengthening exercises using the device both activate and increase the strength of the diaphragm, abdominals, and pelvic-floor muscles. In this study, we prospectively investigated potential risk factors associated with the development of OVF in the middle-aged and older women, including physical function such as abdominal trunk muscle strength measured using this device.

METHODS:

We enrolled 197 female patients aged ≥50 years who were scheduled to undergo surgery for lower extremity degenerative diseases at our hospital. Preoperatively, patient anthropometric and muscle strength measurements, a bone mineral density measurement of the lumbar spine (L-BMD), and full-spine standing radiographs to examine the presence of old OVFs and spinopelvic sagittal parameters were obtained. Three years postoperatively, we evaluated 141 patients who underwent full-spine standing radiographs to identify new non-traumatic OVFs. We excluded 54 patients who did not undergo a second radiographic examination and two patients with new traumatic OVFs. Univariate and multivariate analyses were performed to identify risk factors associated with new non-traumatic OVF occurrence. Finally, receiver operating characteristic (ROC) curve analysis was used to determine the optimal cutoff for the occurrence of OVF.

RESULTS:

Ten (7.1%) patients had developed new non-traumatic OVFs during the three-year study period (fracture group). The fracture group patients had less abdominal trunk muscle strength and lower L-BMD, smaller sacral slopes, and larger pelvic tilt than those in the non-fracture group. The fracture group showed a higher prevalence of old OVFs preoperatively compared with the non-fracture group. In a multivariate analysis, abdominal trunk muscle weakness (p=0.037), low L-BMD (p=0.011), and the presence of old OVFs (p=0.023) were found to be significant risk factors for OVF occurrence during the study period. ROC analysis showed that AMTS values ≤4.0 kPa (95% CI 0.643–0.909, P = 0.004, area under curve 0.776) and L-BMD values ≤1.11 g/cm^2 (95% CI 0.575–0.833, P = 0.032, area under curve 0.704) best predicted the occurrence of OVF in the study cohort. The occurrence rate for new OVFs was significantly higher in patients with AMTS values ≤4.0 kPa (16.1%, 9/56) than in those with AMTS values >4.0 kPa (1.2%, 1/85, P = 0.001). Similarly, the occurrence rate for new OVFs was significantly higher in participants with L-BMD values ≤1.11 g/cm2 (11.0%, 9/82) than in those with L-BMD values >1.11 g/cm2 (1.7%, 1/59, P = 0.031).

DISCUSSION AND CONCLUSION:

Low BMD and old OVF are well known predictors of OVF occurrence. The present study is the first to focus on the effect of abdominal trunk muscle strength on OVF occurrence in middle-aged and older women in a prospective study, and to report the abdominal trunk muscle weakness as a novel risk factor for OVF occurrence. The strength of the abdominal trunk muscles, as measured using the device, is created by the contraction of all deep and superficial abdominal core muscles to increase intra-abdominal pressure thus, creating a semirigid cylinder surrounding the spinal column. Therefore, the muscle strength is capable of relieving some of the imposed stress on the vertebral column. In conclusion, abdominal trunk muscle weakness, old OVFs, and low L-BMD were associated with future OVF in middle-aged or older adult women. The strength measurement can be a risk assessment of OVF.
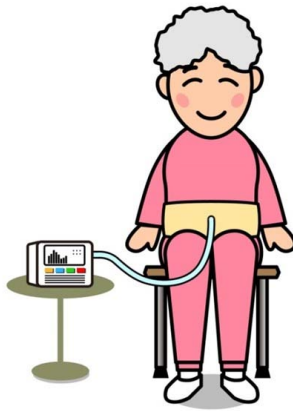
Fig 1. Innovative exercise device for the abdominal trunk muscle.
(Left) Photograph of the device (Right) Illustration of a device-equipped subject