Low-back Joint Moment and Tissue Oxygenation Level During Patient-handling Task Using Kinematics Inverse Dynamic Technique and Near-infrared spectroscopy

Douglas MORI (Prefectural University of Hiroshima)
Hiroshi SUMII (Prefectural University of Hiroshima)
Mitsuhisa SHIOKAWA (Prefectural University of Hiroshima)
Adn Feby ABDILLAGH (Prefectural University of Hiroshima)

1. Introduction
According to the statistics of the Japanese Health, Labor, and Welfare Ministry, the proportion of the elderly 65 years or older reached 20.8% in fiscal year 2006, and is estimated to reach 39.6% in 2050. Subsequently, various health issues occur in caregivers in nursing homes. This occupational condition is related to activities requiring repetitive lifting and repeated activities for which anomalous postures. Additionally, caregivers have high prevalence rates of low back pain and a high incidence of worker’s compensation claims for back injuries. So is feasible to suppress the increase of the cost is effective to slow down the growth of medical cost for work-related low back pain in Japan. Prevention of low back pain in workplace might also be effective to some extent (Itoh, Kitamura, and Yokoyama 2013). Therefore, mechanisms to understand the overuse of the muscle of back is inquiry to determine the physical performance by evaluating the recovery time (Buchheit and Ufland 2011). Therefore the aim of this was to investigate the low-back loading internal forces (kinematic) and tissue oxygenation (hemodynamic) during common patient-handling task. As well as the half time to recovery (hTR) based on tissue oxygenation index (TOI).

2. Methods
Eleven female subjects (age = 18.8 ± 0.7 years, height = 1.59 ± 0.0 m, BMI = 20.1 ± 1.8; mean ± SD) without formal training in patient handling with no previous history of back pain nor circulatory diseases performed three different tasks: a) Elevate the manikin (height = 1.60 m, weight = 13 Kg) from a supine position in the bed to sitting position and b) Transferring the manikin from sitting on the bed to sitting in a wheelchair.

Kinematic measurements
A 3D motion analysis system that include 12 infrared cameras (VICON, UK) and two force plates (AMTI, USA) were used to record kinematic and kinetic data at a sample frequency of 100 Hz. The Plug-In Gait marker protocol was used. Additional markers were placed on the L4/L5 lumbar level and both sides of trochanter. A dynamic 3D biomechanical model of the lower part of the body including feet, legs and pelvis was used for calculating the compression force and net moment at L4/L5 joint. Ground reaction forces were measured by two force platforms.

NIRS measurements
Using the manufacturer’s custom-designed optically dense black holder, two Spatially Resolved NIRS probes (NIRO-200NX, Hamamatsu Photonics, Japan) were placed (via double-sided adhesive tape) bilaterally at the level of the third lumbar vertebra over the ESM, 3 cm lateral from the spinous process (Albert et al. 2004; Kell and Bhamhuni 2006). NIRO-200NX provides a TOI (expressed in percentage) and displays relative changes in oxyhemoglobin (O2Hb) and deoxyhemoglobin (HHb) (expressed in ΔμM). The hTR is the time
it takes to reach 50% of the difference between TOI at the end of the contraction phase and the recovery period. All TOI parameters were analyzed using calculations obtained by monoexponential curve fitting (Allart et al. 2012; Buchheit and Ufland 2011; Chance et al. 1992; Ding et al. 2001; Motobe et al. 2004; Olivier et al. 2013).

3. Results

The trend of one example subject TOI change level during Sitting and Wheelchair assistance and Recovery period is shown in Figure 1 and 2. At the onset of each trial, the oxygenation change considerably decreased in the ESM. This observation might be due to the slight interruption of oxygenation during the movement. Reoxygenation process and gradually increase of tissue oxygenation index is seen in the Recovery period.

4. Discussion

To our knowledge, this is the first report indicating recovery time based on NIRS after simulated patient handling movement on erector spinae muscle in terms of internal forces analysis and metabolic responses recorded simultaneously. One of the metabolic consequences of high intensity, short-duration muscle contraction is impaired subsequent performance. While factors such as substrate depletion and thermal stress may strongly contribute to fatigue during prolonged exercise, the precise mechanisms responsible for fatigue during brief high-intensity exercise remain unclear. In our study, we could demonstrate the TOI, lumbar joint moment and the lumbar compression force during the patient handling test. As for hemodynamic approach, we could demonstrate that adequate blood supply is an essential component to withstand fatigue and prevent the loss of lumbar muscle function. The low back pain is related to a variety of occupational risk factors, one of which is prolonged static contractions of the erector spinae muscle. In occupations such as caregivers static postures have been implicated when transferring patients. A repetitive and static movement that has potentially produces chronic pain. In this study, reiterates the importance of maintaining muscle oxygenation between different patient handling movements of the ESM and prevent low back pain in caregivers.

References

