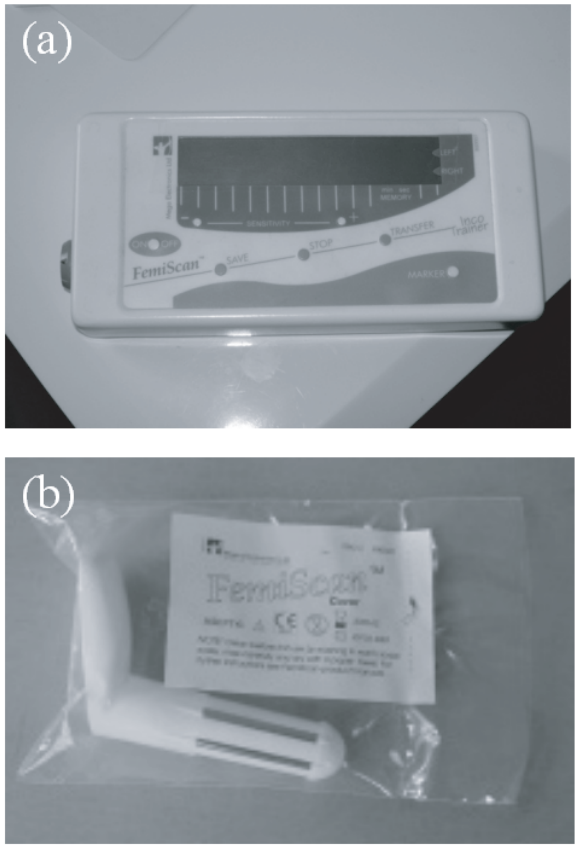


Fig. 1. A biofeedback system (FemiScan Co. Ltd., Finland). The main body (a), a disposable electrode that can be inserted into perineal muscles (b).

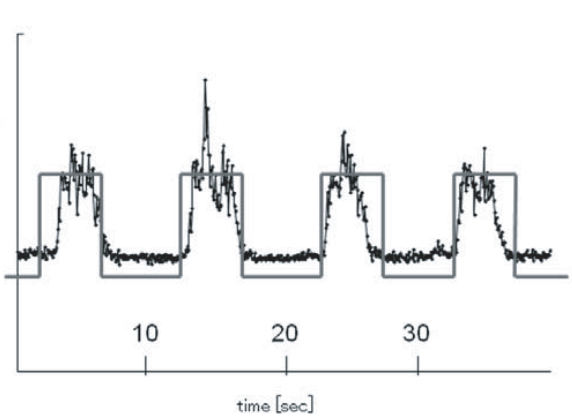


Fig. 2. Biofeedback training instruction signal. The BFT instruction signal produced by superimposing the ARS on the target instruction signal.

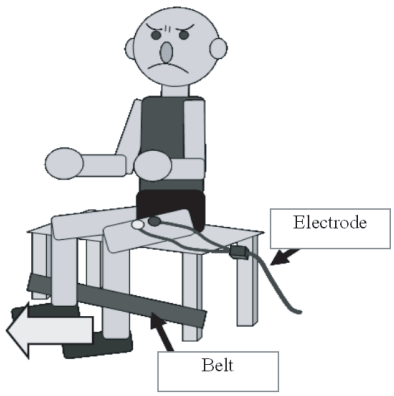


Fig. 3. Biofeedback training of femoral rectus muscles (Takada *et al.*, 2007).

*al.*, 1996). The direct medical expenditure incurred for the care of these people is estimated to be >$15 billion annually, in addition to the $35.2 billion incurred annually for nursing home residents (Peek, 1995). There is a consensus that in most cases, behavioral treatment modalities, including biofeedback, should be used before invasive modalities such as surgery.

A biofeedback instrument has three tasks (Peek, 1995): i) To monitor (in some way) a physiological process of interest; ii) To measure (objectify) what is monitored; and iii) To present what is monitored or measured as meaningful information. The contributions of many previous researchers and practitioners can be cited as the forerunners of biofeedback. Edmund Jacobsen commenced research at Harvard in 1908, and throughout the 1920s and 1930s worked to develop progressive muscle relaxation as an effective behavioral technique for the alleviation of neurotic tensions and many functional medical disorders (Jacobsen, 1938). He used crude electromyographic equipment to monitor the levels of muscle tension in his patients during the course of treatment. The classification of and historical perspectives on biofeedback applications can be found in Gatchel and Price (1979), Gaarder and Montgomery (1981), and Basmajian (1989).

Recently, the rapid atrophy of the muscles used for bending at the hip joint during walking (flexor muscles around the hip joint) with age has drawn attention. The flexor muscles around the hip joint consist of the femoral rectus and abdominal muscles. It has been indicated that a lack of these muscles is responsible for the falling of the elderly. In this study, we examined the ARS of the femoral rectus muscles performed during the BFT of the dominant leg, using the measurement parameters mentioned above, and evaluated changes with age.

## 2. Materials and Methods

### 2.1 Biofeedback training

Temporal data were obtained using sEMG, and they are expressed here as $\{y(t)\}$. Generally, sEMG data are recorded by a computer at 2 kHz. Here, the integral calculation was performed every 0.1 s using the following equation:

$$y(t) = \sum_{k=0}^{99} |x(t + 0.001k)|, \tag{1}$$

and the ARS $\{x(t)\}$ was calculated in real time and outputted. The subject was told to observe the outputted wave patterns and the rectangular waves $f(t)$ of a 10-s cycle superimposed on the same display (Fig. 3), and then perform intermittent continuous contractions of the femoral rectus