An electronic musical instrument approach to training of expiratory and hand muscle movements

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Introduction Typical rehabilitation for the elderly and patients with progressive neurodegenerative diseases is gait training to prevent disuse syndrome, but other training such as expiratory muscle training and exercise to maintain hand dexterity are also recommended. However, these training programs are simplified and maintaining motivation to continue on a regular basis is a challenge. In order to get patients to continue training and be effective, tools that provide enjoyment need to be developed. It has also been suggested that activities that support neuroplasticity, such as music making, are effective in reacquiring motor and cognitive skills in patients with neurodegenerative diseases and stroke patients (Eckart et al., 2020). Therefore, we developed a training support tool that incorporates musical elements. **Purpose** To produce a playful rehabilitation tool that functions as a manipulation training tool for respiratory and hand muscles. It is a the recorder-shaped electronic musical instrument. The device is designed to maintain finger dexterity by pressing multiple buttons and to prevent loss of expiratory muscle strength by blowing in strong breaths. **Method** Our electronic musical instrument consists of a microcontroller Arduino, pushbutton switches and a thermistor that responds to exhalation temperature (Figure1). In expiratory muscle training, expiratory pressure is generally used as an indicator. Many expiratory pressure sensors measure the temperature of the exhaled air, which is converted to flow velocity, and then the volume of air is used to estimate expiratory pressure. In our instrument, we simply used a thermistor. When the exhalation temperature exceed the threshold value, a note is played corresponding the pressed button. The set value is determined from the expiratory temperature and room temperature when the user is asked to blow with maximum force at the start of the program. Because many users have deformed fingers, muscle weakness, and limited range of motion, the controller body was created using a 3D printer that scanned the 3D shape of the user's hand and modified the shape to allow for button placement and wiring (Figure 2). The push buttons are positioned in accordance with the range of motion of the fingers. **Results** The use of electronic instruments tailored to physical characteristics such as deformed fingers and decreased expiratory pressure creates new motivation to play favorite songs. Unlike passive training, this is a spontaneous activity, and thus continuous activity can be expected. With the help of collaborators, we confirmed whether the fabricated items actually played a role in maintaining finger dexterity and preventing expiratory muscle weakness. The collaborator is a woman in her 50s who used to play the recorder frequently. We gave them a printed copy of the Imperial March (composed by John Williams , from Star Wars Episode V "The Empire Strikes Back") sheet music and asked them to record how far they could blow it once a day. We also asked them to comment on the operability of the controller. As a result, the collaborator reported that he was able to play 4 bars on the first day and 23 bars (one chorus) on the second day. Two additional simple songs (Frog Song and Twinkle, Twinkle, Twinkle Star) were played voluntarily each day. From the collaborator's comments, it was reported that our instrument was, in a manner of speaking, operable to the extent that one could play a tune and apply a breathing load. However, the position of the buttons on the controller was a little difficult to use, and it was necessary to make the shape of the controller easy to grasp with light force and to move the fingers. We will therefore improve the method of taking a mold of the subject's hand. In addition, since the sound did not stop immediately after the subject stopped blowing, it was necessary to improve the installation method of the exhalation sensor. As described above, although our instrument has some challenges to complete, the collaborators voluntarily played additional pieces of their choice, suggesting that we can approach the spontaneous training that we aimed for.

References

Eckart Altenmüller, ClaraE.James, J. (2020). The impact of music interventions on motor rehabilitation following stroke in elderly, 407-432. https://doi.org/10.1016/B978-0-12-817422-7.00016-X

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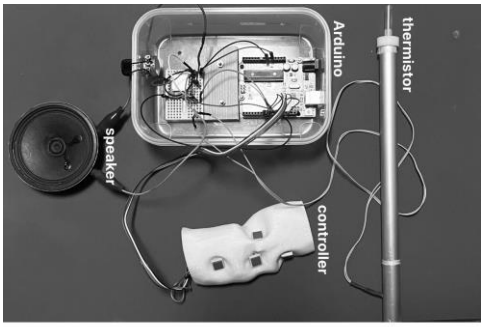

Figure 1. Overall structure. The thermistor is housed in an aluminum cylinder. Sound comes from the speaker.

Figure 2. Control part made using 3D scanning.