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Learning Support for Center of Gravity Movement in Skiing Motion Using Vibration Feedback for Novice Skiers

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In recent years, the number of people participating in skiing has been declining. According to the Leisure White Paper 2019, skiing, participation has decreased from 7.2 million in 2009 to 3.8 million in 2018, nearly half in about 10 years. The sport of skiing is a sport that takes place in nature and requires a specific location, such as a wide slope as exists in the mountains, and enough snow to run on. Therefore, novice skiers may not be able to practice in the first place because there are no ski resorts nearby or there is no snow on the mountain. Thus, the high hurdle to skiing progression is considered to be one factor in the decline in the number of people participating in skiing. Against this background, previous research has focused on training systems for beginners that utilize ski simulators and on supporting skill learning using sensors. In this study, we utilize a ski simulator to clarify the characteristics between novice and expert skiers based on the sensing data that can be obtained during use and aim to provide feedback of the acquired data to novice skiers to teach them how to improve.

In sports, since physical feedback is considered important for improvement, systems that provide real-time feedback during exercise are widely developed. There are a variety of feedback methods, including visual feedback, which provides feedback through a person's eyes, tactile feedback, which provides feedback by stimulating a person's sense of touch, and auditory feedback, which provides feedback through a person's ears. Our previous research used visual feedback to present the difference between the skier and the expert during exercise. However, visual feedback has the aspect that the feedback affects the movement itself, such as being distracted by the visual information of the feedback. Therefore, we thought that it would be better to feedback information without interfering with the skiing motion. While visual feedback is effective when the subject is in a constant state of movement, as shown in the research on core training, we thought that non-visual feedback might be more effective when the subject is moving quickly, such as in skiing. Studies on tactile feedback and auditory feedback suggest that both are effective for feedback while working. Tactile feedback can be given directly at the point where the transducer is attached to the body, and the intensity of the stimulation can be varied. Auditory feedback differs from tactile feedback in that the only part of the body that receives feedback is the ear. Therefore, in this study, we considered the possibility of inducing the subject's movement by using vibration feedback that directly stimulates the body, considering the fact that the subject is in motion and that the point does not affect the subject's movement.

In addition, one of the important factors in the skiing motion is the motion of the center of gravity and the skis in conjunction with the skis during the transition from one turn to the next. We thought that if we could support the center of gravity movement in the skiing motion, the efficiency of skiing improvement would increase. Therefore, in this study, we utilize a ski simulator to clarify the characteristics between beginners and experts based on the sensing data that can be obtained during use and provide real-time vibration feedback of the acquired data to beginners to support their learning of center of gravity movement.

In this study, a VibroTransducer vp210 was used for vibration feedback. The amplifier required for the transducer that generates the vibration was used with a Bluetooth-capable amplifier to enable wireless communication between the vibration device and a PC. In addition, since it vibrates during skiing, it may interfere with skiing when connected by wire. Therefore, we used a Bluetooth amplifier module, XY-P15W, which enables wireless communication to minimize the impact on skiing. By using wireless communication between the amplifier and the PC that outputs the audio, wiring can be eliminated. In addition, the use of a small amplifier module instead of a large commercially available amplifier makes it suitable for vibration feedback during skiing, since it is less likely to be disturbed during exercise.

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In the experiment, novice skiers were divided into two groups: one with and one without the vibrating device, and the group with the system practiced while receiving vibration feedback during practice. The data from the test runs will be treated as an evaluation of the results. The number of experiments was one run in the condition before starting practice, seven practice runs, and seven test runs, for a total of 15 runs. Because of the large number of runs, it was deemed difficult to complete all of them in one experiment, so the number of experiments was divided into four sessions and conducted twice a week for two weeks.

The method of analyzing the experimental results was to calculate the center of gravity based on the pressure data acquired, and to calculate the error between the movement of the center of gravity of the skilled person and that of the subject. By looking at the trend of the calculated error, the presence or absence of improvement is evaluated. The error is calculated by using the average absolute error for the center-of-gravity data in the time series data. The error of each test is calculated in comparison with that of the expert, and the change is evaluated by repeating the number of trials. Calculations are performed on the x-coordinate and y-coordinate of the center-of-gravity data, respectively. Since different subjects have different physiques and weights, which can cause differences in the pressure applied to the boots, the center-of-gravity data of the skilled and the subject are normalized before calculating the error with the skilled.

In the post-experiment questionnaire, several subjects commented that it was difficult for them to move their bodies immediately after the vibration. Changing one's own movements immediately after real-time feedback is difficult and needs to be considered.

However, although it is difficult to reflect one's own movement immediately after real-time feedback, there were signs that one can improve one's movement based on feedback that comes repeatedly in the case of repetitive movements such as skiing. In addition, the results of the post-experiment questionnaire suggested that the system was able to recognize the direction of vibration during the skiing motion.

Although load data was used in the experiment with respect to the evaluation of skiing progress, feedback through vibration is a direct stimulus to the body and may lead to correction of posture in the given area. It is thought to help correct posture, but since only load data was used in this study, the effect could not be verified. Posture data could also be used to further validate the usefulness of this system.