CHANGE IN MUSCLE ACITIVITY DURING SKIING USING 2 SIMULATORS

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This research analyzed the change in lower muscle activity during skiing using two simulators. Participants in this study were 8 male adults who held a certificate issued by the Korea Ski Instructors Association. Kinematic factors when skiing on two types of simulators were compared and analyzed. Most subjects maintained a higher value of %MVIC while repeating the positions on the Pro Ski Simulator than Skiers Edge. Efficient skiing on ski-simulators requires the maximum use of skiing time on each foot and the ability to quickly flex and extend the hip and the knee joints. Furthermore, differences between individuals exist depending on the level of ski technique and the type of simulator and it is believed that the development of an additional adjustment apparatus in the existing equipment is necessary to enable safe and effective motions.

KEY WORDS: skiing analysis, ski simulator, ski exercise, winter sports.

INTRODUCTION: A simulator is the imitation and replication of a system or a process using various means; the ski-simulator, although not real, is a technology that can replicate a situation similar to reality, and it helps skiers experience the sense of skiing even in non-sloped conditions and confined spaces. And EMG activations and ground reaction force measured while skiing on simulators were lower than on snow. Although less overall EMG activations was present on the simulators, the pattern of EMG activity was closer to real snow(Fausto, Giuseppe & Nicola, 2013). Currently, various simulator products are produced by many organizations, and ski-simulators are used for personal and public rehabilitation, as well as training. If the purpose of the ski-simulator is to provide effects similar to actual skiing, it should encourage accurate posture and provide kinematic information that can be helpful in injury prevention. This research analyzed the change in lower extremity angles of skiers and the effect on muscle activity during skiing using two of the widely used ski-simulators.

METHODS: Participants in this study's experiment were 8 male adults(average age: 29.25 ± 3.20, average height: 177.25 ± 6.02 cm, average weight: 72.75 ± 7.02 kg) who held a certificate issued by the Korea Ski Instructors Association. The two types of ski-simulators(Skier's edge; UK, and Pro ski simulator; Slovenia) were fixed onto a flat surface(figure 1); for accurate results, sufficient time was given to each subject for practice, and then, the actual skiing footage was filmed for 30 seconds. No special control was applied to the hands holding the poles.

The performance principle and equipment specification is almost the same, but each ski-simulator was categorized from one (lowest) to six (highest) intensities and from one (lowest) to ten (highest) stages. The middle intensities of three and five for each respective ski-simulator were used for the study. To remove the effect of experiment order on results, the order of the movements performed on the two simulators was randomly chosen. After the first trial, sufficient rest was given, and the second trial was conducted. EMG signals of eight muscles of interest were selected on the both leg, and skin preparation and electrode placement over the intended muscles were performed in accordance with the SENIAM concerted protocol(Hermens, Freriks, Disselhorst & Rau, 2000).

We measured the MVIC (Maximum Voluntary Isometric Contraction) of the individual muscles and the position of sticking the surface electrode was established to be Rectus Femoris (RF), Biceps Femoris (BF), Tibialis Anterior (TA) Gastrocnemius (GC) and the sampling frequency was established to be 1024 Hz. Participants'' performance were statistically processed using SPSS 21.0. The paired t-test was conducted and differences were considered statistically significant at a p-value of less than 0.05.

Figure 1: Two type of ski simulator(left; pro ski simulator, right; skier's edge)

RESULTS: Observation of lower-extremity muscle activity (Table 1) show that for the rectus femoris, skiing on the Pro Ski Simulator (44.17%) exhibited more muscular activity than Skiers Edge (28.66%), and the difference was statistically significant ($p < .001$). When skiing on the Pro Ski Simulator, most subjects maintained a high value of %MVIC while repeating the positions. For the bicephalus femoris, skiing on the Pro Ski Simulator (20.83%) showed a higher %MVIC value than Skiers Edge (14.31%), and the difference was statistically significant ($p < .001$). For the Tibialis anterior, skiing on the Pro Ski Simulator (42.10%) showed a higher %MVIC value than Skiers Edge (28.97%), and the difference was statistically significant ($p < .05$). For the gastrocnemius on the Pro Ski Simulator (30.65%) showed a higher %MVIC value than Skiers Edge(21.11%), and the difference was statistically significant ($p < .01$).

Table 1
Comparison of the muscle activity(%MVIC)

	Rectus Femoris	Biceps Femoris	Tibialis anterior	Gastrocnemius
Skier's edge	28.66±7.41	14.31±2.73	28.97±8.20	21.11±3.31
Pro ski simulator	44.17±8.73	20.83±3.30	42.10±11.51	30.65±4.75
t	-3.989	-5.564	-2.431	-4.592
p	.005**	.001**	.045*	.003**

* : $p<.05$, ** : $p<.01$, *** : $p<.001$

DISCUSSION: Results of the observations of the lower extremity muscle activities in this study showed that skiing on the Pro Ski Simulator showed a higher %MVIC value in the rectus femoris ($p < .001$), bicep femoris ($p < .001$), tibial muscle ($p < .05$), and gastrocnemius ($p < .001$) than skiing on Skiers Edge, and the differences were statistically significant. When skiing on the Pro Ski Simulator, most subjects maintained a high %MVIC value while repeating the movements. In a preceding study by Panizzolo, Petrone & Maroolin (2010), muscle activity while skiing on snow was high, with 65.4% MVIC for the midvastus, and 42.6% MVIC for the rectus femoris. On Skiers Edge, muscle activity was 38.7% MVIC for the midvastus, and 25.1% MVIC for the rectus femoris. On Ski Magic, muscle activity was 33.4% MVIC for the midvastus, and 21.0% MVIC for the rectus femoris. In this present study, on Skiers Edge, a similar result of 28.66% MVIC was observed for the rectus femoris, and a similar muscle activity level was observed for 44.17% MVIC on the Pro Ski Simulator in the present study and 42.6% MVIC on snow in the preceding study. As such, the high muscle activity of all parts including the rectus femoris shown on the Pro Ski Simulator in this study is thought to be a compensatory mechanism for maintaining sufficient range of motion (flexion-extension) in the lower extremity joints; the skiing motion performance on the Pro Ski Simulator showed a higher muscle activity than on Skiers Edge, and this is believed to greatly affect momentum.

As observed, efficient skiing on a ski-simulator requires maximum use of skiing time on each foot and the ability to quickly flex and extend the hip and the knee joints. However, differences between individuals exist depending on the level of ski technique and the type of simulator; the result of this study indicate that skiing can be performed in a stable manner

using Pro Ski Simulator for experts, and Skiers Edge for non-experts. It is also believed that the development and application of a segmental muscular training program will be required in the future for injury prevention, and the development of an additional adjustment apparatus in the existing equipment will also be necessary to enable safe and effective systematic motion of both the upper and the lower body.

CONCLUSION: In this study, kinematic factors when skiing on two types of ski-simulators were compared and analyzed. To this effect, muscle activities were calculated, and the differences in the two simulators were investigated. When skiing on the Pro Ski Simulator, most subjects maintained a high value of %MVIC while repeating the positions. For the rectus femoris (44.17%), bicephalus femoris (20.83%), tibialis anterior (42.10%), gastrocnemius (30.65%) on the Pro Ski Simulator showed a higher %MVIC value than Skiers Edge, and the difference was statistically significant. Efficient skiing on ski-simulators requires the maximum use of skiing time on each foot and the ability to quickly flex and extend the hip and the knee joints. Furthermore, differences between individuals exist depending on the level of ski technique and the type of simulator; the result of this study indicate that skiing can be performed in a stable manner using Pro Ski Simulator for experts, and Skiers Edge for non-experts, and it is believed that the development of an additional adjustment apparatus in the existing equipment is necessary to enable safe and effective motions.

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