

INFLUENCE OF SKI BOOTS ON BALANCE PERFORMANCE AND INTERMUSCULAR COORDINATION

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INTRODUCTION

The development of carving skis in alpine skiing has increased the importance of balance and proprioception training for skiers. Recent work stressed the importance of combining classic ski conditioning with proprioception training in ski racing (Raschner / Müller, 2001). Little is known about the influence of ski boots during proprioception training. Noé & Paillard (2005) compared national to regional ski racers in an unstable position with and without ski boots. These tests were performed two-legged on a force platform. The 2 groups had similar results with ski boots, but the national skiers were worse without ski boots. This may be a long term effect of more time spent wearing ski boots, which leads to decreased proprioception in the ankle joint which in turn reduces balance performance. Balance and proprioception training is used as a preventive measure for injuries in alpine skiing, but little research has been done. Therefore the aims of this study were to analyse the influence of ski boots on: a) balance performance of alpine skiers with different skill levels and b) muscle activation.

METHOD

84 experienced skiers (ES) and 66 ski racers (SR) of the Skigymnasium Stams were tested two-legged with and without ski boots with the MFT S3 Test. The MFT S3 Test is a reliable and valid balance measurement system for performance and sensorimotor regulation during a lateral and a forward/backward test. The test system consists of an uniaxial unstable platform with an integrated sensor, which records all discrepancies in the horizontal plane. All fluctuations of the center of gravity are measured and transformed into stability, sensorimotor and symmetry indexes to define the individual state of balance. An index of 1.0 is perfect, and the index increases as the test deviates from perfect. In this study skiers were tested two-legged, with and without ski boots in the lateral setting (Figure 1). Testing time was 30 seconds for each trial. Additionally 10 ES underwent the same test with surface electromyography (EMG) to assess intermuscular activity of the M. peroneus brevis (PB), M. tibialis anterior (TA), M. gastrocnemius lateralis (GL), M. vastus lateralis (VL), M. biceps femoris (BF), M. obliquus externus abdominis (OE) and M. lumbar erector spinae (LES). EMG-data were recorded and processed with Noraxon MyoResearch 2000. For statistical analysis (SPSS 12.0, $p < 0.05$) a Kolmogorov-Smirnov-Test (examination of normal distribution), a dependent and independent t-test (to test for differences between the two test situations, skill levels and gender) were used.



Figure 1
MFT S3 test

RESULTS

There were no significant differences between males and females when genders (all skiers together) were compared. Females had mean sensorimotor indexes of 3.06 ± 1.09 without ski boots and 3.79 ± 1.24 with, males had mean sensorimotor indexes of 3.07 ± 1.05 without ski boots and 3.84 ± 1.03 with. A comparison of tests with and without ski boots produced a highly significant difference ($p \leq 0.001$). As shown in table 1 balance was significantly better barefoot than in ski boots. The SR were in every test significantly better than the ES. Figure 2 displays the mean EMG activity during the lateral test. The group means shows no significant difference between activation, but there are major differences within the group.

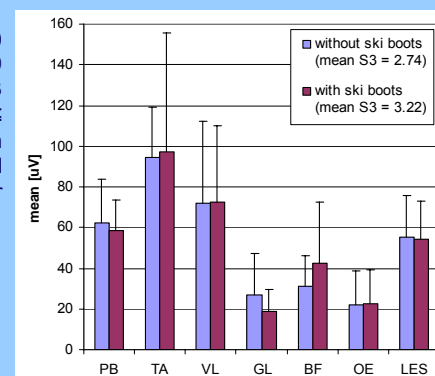


Figure 2 EMG – mean activity

	♀ ES	♀ SR	♂ ES	♂ SR
without ski boots	3.53 ± 1.00	2.35 ± 0.79	3.58 ± 0.95	2.39 ± 0.76
with ski boots	$4.37 \pm 1.05^{***}$	$2.88 \pm 0.92^{***}$	$4.22 \pm 0.87^{***}$	$3.33 \pm 1.02^{***}$

*** highly significant ($p \leq 0.001$) differences without ski boots vs. ski boots

Table 1 Sensorimotor Index – MFT S3 Test lateral

DISCUSSION AND CONCLUSION

The results of this study concur with Noé & Paillard (2005) – ski boots have a negative influence on balance performance. However in this study ski racers were better in all test situations than normal skiers. This may be due to balance and proprioception training, which is a major training focus for the athletes in Stams. Most ski racers train balance barefoot, so a focus is set on the ankle joint. This could be a reason for the good sensorimotor indexes in the barefoot test situation as well as for the better indexes with boots of the ski racers. No evident pattern in the change of muscle activation with ski boots was found, as each subject had an individual strategy to maintain balance when wearing ski boots. With the restricted range of movement in the ankle joint, some corrected more through the knees and others more through the hips.

Proprioception training has been recommended throughout the literature for rehabilitation after knee and ankle injuries or prevention of such injuries. Many studies have been published in team sports, especially in volleyball (Verhagen, 2004). Due to the large number of ACL injuries in recreational skiing and ski racing, proprioception training should be concentrated more on knee stability to be ski specific. This could be achieved by stabilizing the ankle joint with ski boots or ankle braces. Gruber et al. (2006) recommend ankle fixation during sensorimotor training to increase neuromuscular strain of the knee muscles and to improve the agonist/antagonist communication. Proprioception training programs with ankle fixations are important in rehabilitation, but should be stressed in alpine ski conditioning programs to aid in ACL injury prevention. Recreational skiers should integrate balance training programs in their training process as it may prevent injuries and improve balance performance during skiing.

In contrast to these studies Kröll et al. (2006) developed and analyzed the function of a special training device (SensoWip) between the ski and the binding during a giant slalom training. This training aspect could be seen as a first approach to train the specific balance performance for modern ski technique training on the snow.

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