INFLUENCE OF STANCE WIDTH AND BINDING ANGLES ON TIBIAL ROTATION AND OLLIE JUMP HEIGHT IN SNOWBOARDING

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The purpose of this study was to investigate the influence of stance width and binding angles on tibial rotation during a flat landing of a drop jump and Ollie jump height in snowboarders. Six binding conditions combined of three stance widths and two binding angle setups (forward and duck stance) were tested on 10 expert freestyle snowboarders. Relating to knee injury risk, tibial rotation was assessed using skin markers during the flat landing of a 51cm drop jump. The influence on the performance was investigated by the assessment of the Ollie jump height using a Quattro Jump force plate. An influence of the binding parameters on tibial rotation during a flat landing was found, whereas Ollie jump height didn't differ significantly. A bigger angle of the front foot and a negative angle of the rear foot reduced the magnitude of internal tibial rotation.

KEY WORDS: snowboarding, stance width, binding angle, tibial rotation, jump height, landing.

INTRODUCTION: Despite the large popularity of snowboarding there are no evidence-based recommendations relating to the binding parameters, such as stance width and binding angles. Regarding binding angles, the two main settings are forward stance (front and back foot directed in driving direction) and duck stance (front foot in and back foot against driving direction). The forward stance is widespread among beginners, carving and all-mountain riders, whereas the duck stance is mainly used by freestyle riders. The recommendations of the Swiss School for Snowboard Instructors (SSBS) include angle configurations of +45°/+10° - +15° for instructors, +45°/0° for jumps and +10° - +30°/-5° - -20° for big air (www.ssbs.ch), whereas Swiss Snowsports does not provide any recommendations (www.snowsports.ch). Also, for the stance width only rules of thumb exist. Summarized, recommendations are mainly based on trends and neither their influence on injury mechanisms of the lower extremities nor on performance are clear.
Whilst in alpine skiing injury rates are more or less constant, injuries in snowboarding are still increasing (Médecins de Montagne, 2011). Generally, in snowboarding the upper extremities are more often injured than the lower extremities (Janes & Abbott, 1999; bfu report, 2011; Médecins de Montage, 2011) and compared to alpine skiing, especially injuries of the knee are less often. However still 9% (bfu report, 2011), 6.8% (Médecins de Montagne, 2011), 17% (Davidson & Laliotis, 1996), respectively 15% (Janes & Abbott, 1999) of occurring injuries in snowboarding are knee injuries. The study of Janes & Abbott (1999) found anterior cruciate ligament (ACL) injuries in 3.4%, and of these ACL injuries, 59% were expert riders. Davidson & Laliotis (1996) stated that 80% of the knee injuries in snowboarding occurred at the front leg and assumed that this could be due to the larger binding angle of the front leg. In agreement to the later finding, in the study of Davies, Tietjens, Van Sterkenburg, & Meghan (2009), in 31 of 35 riders with ACL injuries the front knee was injured and a combination of maximal eccentric quadriceps contraction with internal tibial rotation during a flat landing was discussed as being causal. Concerning ACL injuries, several studies showed that internal tibial rotation is an important injury mechanism, especially in combination with a fully extended knee (Markolf, Burchfield, Shapiro, Shepard, Finerman & Slauterbeck, 1995; Hame, Oakes & Markolf, 2002). Thus, it is unclear if binding parameters influence tibial rotation and following ACL injury risk of snowboarders.
Recommendations on binding parameters should be optimized with the aim of minimal injury risk and maximal performance. Thus, the aim of the present study was to investigate the influence of stance width and binding angles on tibial rotation during a flat landing of a drop jump and Ollie jump height in expert snowboarders.

METHODS: 10 subjects (sex: 2f/8m, age: 22.4 ± 5.2 years, height: 174.9 ± 7.6 cm, weight: 72.9 ± 7.9 kg, stance: 3 regulars/7 goofies), all expert level snowboarders, with no acute lower extremity injuries and no previous knee injuries or surgeries, participated in this study.
Three stance widths were tested: shank length (SL), shank length minus 5 cm (minus) and shank length plus 5cm (plus). Two binding angle combinations were tested: forward stance with +30° front leg and +15° back leg angle (+30°/+15°) and duck stance with +18° front leg and -15° back leg angle (+18°/-15°). Thus, six binding conditions were analysed.
Ollie Jump Height: The jump height of the snowboard Ollie was measured using the force platform Quattro Jump (Kistler). For each condition mean and SD over five valid trials (push-off over back leg and flat landing with both feet on the Quattro Jump) was calculated.
Drop Jump: Tibial rotation was assessed during a drop jump from a height of 51cm in an angle of 45° relative to the landing area onto five force plates covered with carpet (Figure 1).

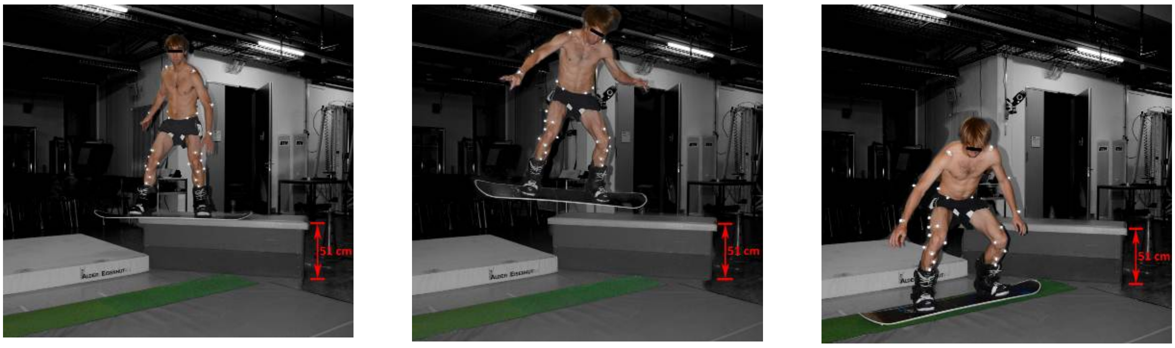

Figure 1: Experimental Set Up Drop Jump.

The 3D motion analysis system used for the kinematic assessment is a 12 camera VICON MX system (Oxford Metrics Group, UK). The used capture frequency was 100 Hz and the capture volume 300 cm x 500 cm x 200 cm. The used marker set for the assessment of the lower extremities is adapted from List (2009) and consists of four shank and five thigh markers. The position and orientation of each segment was determined relative to the reference segments defined by the standing trial using a least-squares fit of the corresponding marker point clouds (Gander & Hrebicek, 1997). Thus, neutral position (0° rotation) was defined by the standing trial. Each segment was defined by a redundant number of markers, aiming in an improvement in orientation accuracy (Challis, 1995). Joint rotations were described from the shank relative to the thigh segment using a helical axis approach (Woltring, 1994). To define clinically interpretable rotational components the attitude vector was decomposed along the axes of the joint coordinate system (Woltring, 1994). The mediolateral axis of the knee joint coordinate system is estimated by a functional approach using a knee flexion/extension basic motion tasks (List, 2009). The direction of the vertical axis is perpendicular to the mediolateral axis and lies in the plane spanned by the mediolateral axis and the functional estimated hip joint center (List, 2009). The anteroposterior axis is perpendicular to the latter two. Rotation around the vertical axis is denoted as tibial rotation. Maxima (max) and minima (min) of tibial rotation were determined during the first 0.15s after impact (vertical force >50N). Range of motion (ROM) is defined as the range between maximal (max) and minimal (min) tibial rotation values (Figure 3). For each condition mean and standard deviation (SD) over five valid trials (flat landing on force plates) was calculated.

RESULTS: The differences of the average Ollie jump height are smaller than 3.6 cm within a given angle configuration and the standard deviations are about 30 % of the average values (Table 1). No significant differences between the binding conditions were found. Nevertheless, it seems that the duck stance with a large binding width might be beneficial for the jump height.

The ROM of the front and back leg was not influenced by the different binding conditions. But there was a shift of the ROM that changed the minimal and maximal tibial rotation angles. The largest angular velocities of the tibial rotation occurred within the first 100ms after the impact (Figure 2). Within a subject a characteristic motion pattern was observed. For all three stance widths, minimal and maximal tibial rotation values of the front leg differed between duck and forward stance (Figure 3). Between the three stance widths, no differences were found for the front leg. For the front leg, there was a shift towards internal rotation with the duck stance. The opposite was observed at the back leg. Here, the duck stance resulted in an external shift (Figure 3). At the back leg, the stance width influenced minimal and maximal tibial rotation angles (Figure 3). An enlargement of the stance width resulted in a larger internal rotation in the back leg for both angle configurations (Figure 3).

DISCUSSION: The kinematics of the lower extremities is influenced by the different binding parameters. It remains unclear, which binding parameters should be chosen for the smallest injury risk. An investigation of knee flexion angles and impact forces are needed to derive recommendations for the prevention of ACL injuries in snowboarding.

The Ollie jump height is a typical movement for competition. Here, the aim of the binding parameters is to achieve a maximal performance of the athlete. The differences between the Ollie jump heights were small and the observed SD rather large. This explains why there were no significant differences, which might change with a larger number of participants. Nevertheless it cannot be excluded that the Ollie jump height is influenced by the binding parameters. A similar reason could explain why the stance width didn't influence the min/max values of the front leg. It's possible that with a larger number of subjects these differences are significant. However, the influence on the back leg remains larger than on the front leg.

Table 1: Ollie Jump Height – mean and SD over all subjects

	+30°/+15°			+18°/-15°		
	minus	SL	plus	minus	SL	plus
Jump height [cm]	29.1 ±7.5	31.7 ± 7.1	30.1 ± 7.5	32.3 ± 9.1	34.5 ± 14.6	35.9 ± 11.3

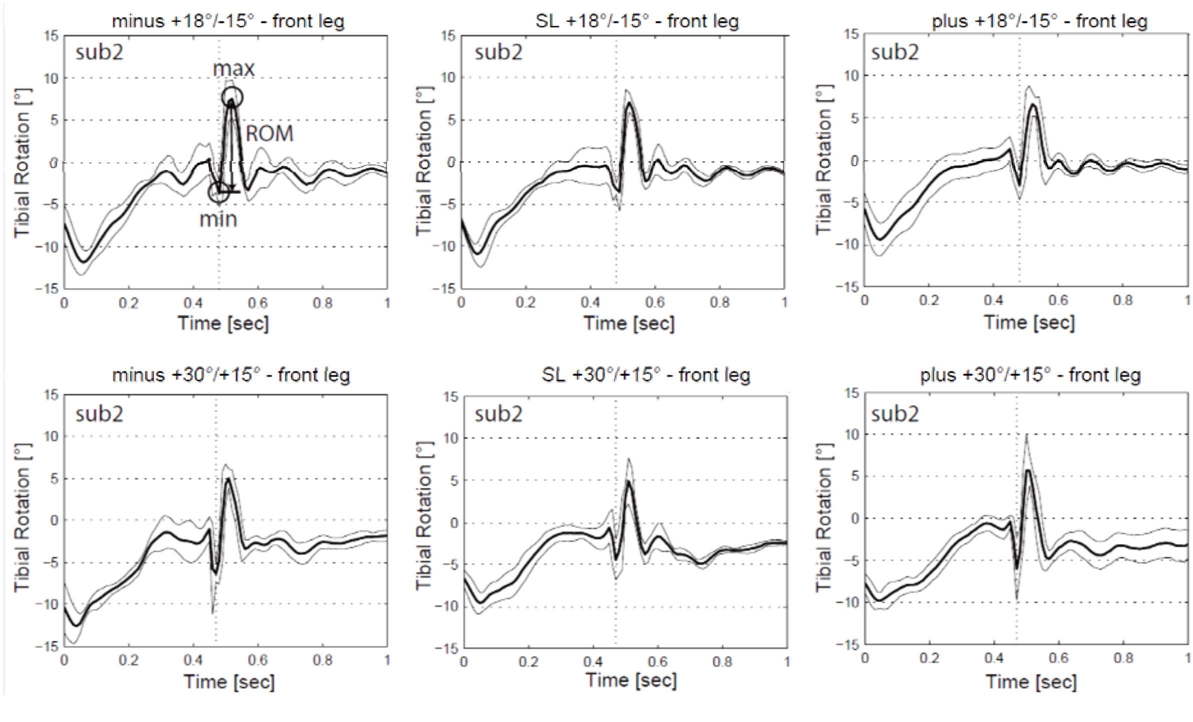

Figure 2: Tibial rotation (internal (+), external (-)) of the front leg during a flat landing for all 6 binding conditions - mean and SD over 5 trials of sub2. Time of impact is shown with the dotted line.

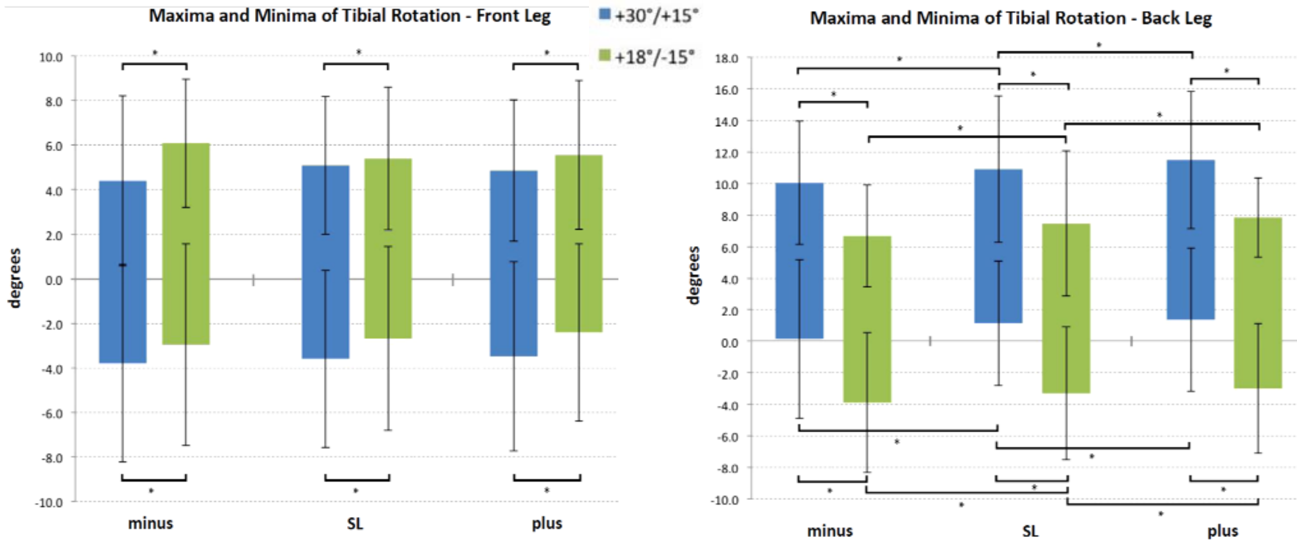

Figure 3: Maxima and minima of tibial rotation of the front leg (left) and the back leg (right) during the first 0.15s after impact for all 6 binding conditions - mean and SD over all subjects. * significant with p<0.5 (repeated measures ANOVA)

CONCLUSION: An influence of the binding parameters on tibial rotation during the landing from a jump can be confirmed. A bigger angle of the front foot and a negative angle of the back foot reduced the magnitude of internal tibial rotation. Ollie jump height didn't differ on a significant level between binding conditions, although small differences may be noted.

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