



## EVALUATION OF LATERALITY IN THE SNOWBOARD BASIC POSITION

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MICHAŁ STANISZEWSKI<sup>1\*</sup>, PRZEMYSŁAW ZYBKO<sup>1</sup>, IDA WISZOMIRSKA<sup>2</sup>

<sup>1</sup> Faculty of Physical Education, Józef Piłsudski University of Physical Education, Warsaw, Poland

<sup>2</sup> Faculty of Rehabilitation, Józef Piłsudski University of Physical Education, Warsaw, Poland

### ABSTRACT

**Purpose.** Snowboarding requires a lateral positioning of the body. Moreover, a person must continuously control their balance and use this in order to manoeuvre on the slope applying properly pressure on the lower limb closest to the nose of the board (the leading leg). The present study is an attempt to determine the interdependencies between side preference while snowboarding and laterality when performing other tasks. The dynamic stability in the neutral standing position, as well as in the lateral positions (left or right) was also evaluated. **Methods.** The survey participants (100 active snowboarders) answered a set of questions concerning laterality while carrying out basic everyday tasks and while doing sports. The respondents were divided into two groups based on their preferred leading side in snowboarding. Additionally, in the case of 34 people, muscle torques values of the lower limbs were measured under static conditions and the postural stability was evaluated using AccuSway AMTI platform and Biodex Balance System platform. **Results.** Over 90% of the participants declared right-handedness and right-footedness. However, with regard to snowboarding, only 66% indicated their right leg as leading. No significant dependence was found between the directional stance on the board and the leading hand, dominant leg, or leading eye. The stability measurements revealed statistically significant differences between the neutral stance and the lateral positioning. **Conclusions.** Based on the study results, it may be assumed that the declared directional stance on the snowboard is not contingent on the person's basic laterality, and that the lateral stance on the board significantly affects the posture control.

**Key words:** biomechanics, posture control, muscle torques, leading lower limb

### Introduction

The combination of three fundamental elements – board's design, the snowboarder's stance and riding technique – determines a snowboarder's performance. However, all of them require an asymmetrical lateral positioning of the body with regard to the slide's direction, and turning is then controlled by leaning outward on the board's edges in the direction of the desired turn. The most difficult element when learning to snowboard is how to control posture. The sideways stance (in snowboarding known as the basic position) on the board is not a natural position for human locomotion, and because the lower limbs are bound, their role in posture control is limited. The direction impulse which results in taking a turn starts when the snowboarder puts their weight on one edge of the board to make it change direction. Therefore, in order to do it, the snowboarder must unbalance themselves in a controlled way and lean into the direction of the intended turn. Stability is maintained during the turn due to the occurrence of an inertial force – which is characterised by the same velocity and magnitude, but is in the opposite direction to the centripetal force. The value of

the inertial force, commonly referred to as the centrifugal force, cancels out the forces which might overturn the snowboarder, and is directly proportional to the square of the rider's velocity and inversely proportional to the curve's radius. In order to stay on the curved path, the snowboarder must lean at a proper angle into the turn maintaining the body's centre of gravity in the centre of the curve – for a greater velocity or a smaller turn radius, the lean angle must be greater [1, 2].

Snowboarding is positively linked with constant balancing. Standing on the board is conditioned by the rider's ability to keep posture control, whilst a turn is executed due to conscious unbalancing. The snowboarder's stability is affected by the size of the base of support; the position of the centre of pressure (COP); the person's body mass; and the direction of the gravitational force [3, 4]. Furthermore, posture control during the slide is affected by the velocity and momentum of the counteracting forces. It is worth noting that the balance control necessary to make a turn requires the rider to lean in the sagittal (anterior/posterior) plane while their head must face the slide's direction, which occurs in the frontal (medial/lateral) plane.

In winter sports such as snowboarding and skiing, posture control is an element that can be assessed in relation to many different aspects [5]. For instance, Platzer et al. [6] evaluated the one-legged stance among members of the Austria national snowboarding team using

\* Corresponding author.

the Biodex Balance System platform. The authors monitored changes in their posture control during successive stages of training and related the gathered data to the specificity of the given competition, combined with the number of points accumulated in the World Cup. In another study, Noé and Paillard [7] evaluated the posture control of amateur skiers and members of the national skiing team. The subjects were evaluated both while wearing skiing boots and without them. Their results showed that in the measurements without boots the amateurs had better posture control than the professionals. In turn, the national team members had far better results when tested in skiing boots, which proves the long-lasting effects of wearing them on their balancing capabilities. Still, this sort of compensation phenomenon occurred only under conditions characteristic of the practiced sport.

In the proper snowboarding technique, the slide trajectory is determined by putting more pressure on the lower limb positioned closer to the nose of the board – the so-called ‘leading leg’ [8]. For beginners, determining the leading limb is essential to an efficient learning process; whereas the reversed slide (with the opposite limb in front) is taught at a later stage of training due to its difficulty. The ability to ride freely with either leg in front requires many days of practice, and attests to a certain level of the snowboarder’s proficiency.

The asymmetry of snowboarding is significantly displayed when freestyle techniques are performed. McAlpine et al. [9] point out that when landing after the flight phase, the pressure on the rear leg is significantly greater than on the limb in the front. After taking into consideration some other additional factors, the authors validate the assumption that, from the perspective of sliding technique and biomechanics, the lower limbs should be assessed separately when determining laterality.

Laterality occurs naturally in the course of human development and applies to several different functions of the human body. The inclination for the organs located on either the left or right side to perform given tasks is comprehensively described in literature. However, basic analyses of functional laterality tend to focus on determining the dominant upper and lower limb when performing basic everyday life and motor activities, such as kicking a ball or writing. The differentiation between dominant side and non-dominant one may also apply to other functions, such as hearing, seeing or brain functions, and generally plays a role in the choice of the best limb to carry out a given task or when rotating the body [10]. Additionally, some researchers have pointed out the differences between each side with regard to: the ranges of motion in specific joints [11, 12], the discrepancies in the anatomy and biomechanical functions of body parts based on the preferred side [13–16] or the differentiation in lat-

eralisation factors stemming from the gender of the study participants [17].

Since at present there are no papers which analyse the relationship between the laterality associated with the choice of the leading lower limb in snowboarding and the person’s functional laterality, this paper will attempt to establish whether there is such a connection, and determine the influence of the snowboarder’s laterality on their body stability.

### Material and methods

The study population included 100 participants who were randomly chosen from a snowboarding course consisting of 46 females ( $21 \pm 4$  years old) and 54 males ( $22 \pm 3$  years old). The participants were asked questions in the form of a survey concerning their laterality while performing basic everyday chores and sports activities. The dominant upper limb was determined based on the respondents’ statements concerning one-handed throwing. Whereas the laterality of the lower limb was not so easy to determine. We needed to take into account many activities involving the use of the lower limbs in human life. Based on this, the laterality in four tasks was determined: ball kicking, one-legged bouncing off the ground after a running start, one-legged stance and the declaration of their leading leg during snowboarding ride (the leg at the front of the snowboard). Additionally, the respondents were asked about their preferred side while looking through one eye and their favoured rotation direction when jumping with both feet with a 360 degree spin. Next, the respondents were divided into two groups based on their leading leg in snowboard stance. Moreover, 34 people participating in a snowboarding instructor’s course (16 females, aged  $22 \pm 1$  year old, mean body mass:  $59 \pm 7$  kg and mean height:  $170 \pm 7$  cm; and 18 males aged  $22 \pm 3$  years old, body mass:  $80 \pm 7$  kg and mean height:  $182 \pm 6$  cm) underwent an assessment of their body stability and an evaluation of the muscle torque in their lower limbs. All of the respondents were informed about the research protocol and were acquainted with the requirements and conditions of the experiment. Also, each participant personally signed an informed consent form prior to participating in the research study, and was notified of their right to leave the experiment without any consequences. The study was approved by the Scientific Research Ethics Committee.

To evaluate the laterality of strength between front and rear leg on the snowboard, measurements of the muscle torques of the flexors and extensors in both knee joints and plantar flexors in both ankle joints were taken under isometric conditions. The participants were examined on a Biodex System 3 Pro machine (USA) in a sitting position with a stabilized torso and their knees bent at  $90^\circ$ .

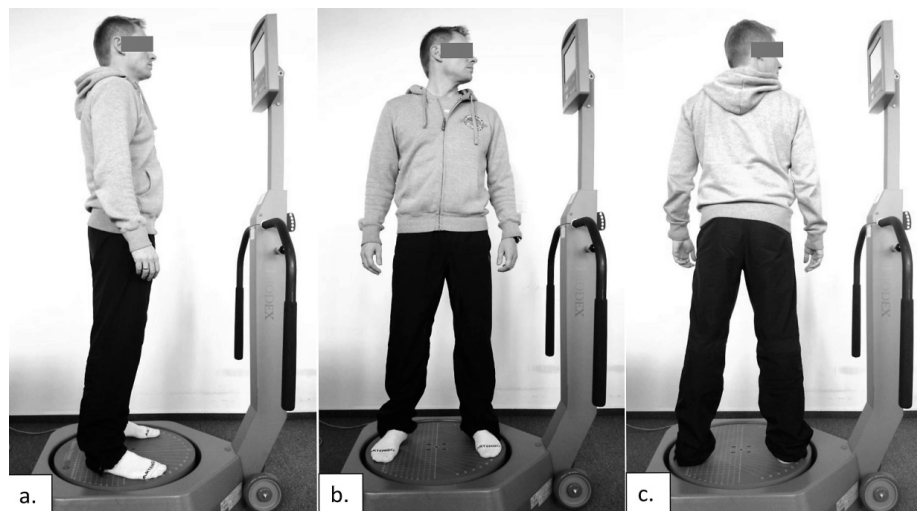


Figure 1. Testing positions during the postural stability assessment under dynamic conditions performed on a Biodex Balance System platform: a) straight, b) left side to the screen, c) right side to the screen

To evaluate the laterality of posture control between front and rear leg on the snowboard, measurements of the static stability were tested on the AccuSway AMTI (USA) stabilographic platform with a stable floor. Testing protocols were performed with the subjects' eyes open and closed in one-legged stances. The path length of the COP was used for comparison of the stability between legs.

Dynamic stability measurements were performed using the Biodex Balance System (USA) platform. Three testing protocols were carried out at the 8<sup>th</sup> level of instability (scale of platform settings), with each protocol consisted of 3 trials – each lasting 20 seconds with a 10-second interval between the trials. A Postural Stability Test (PST) was performed with biofeedback, requiring the participant to stand straight in front of the screen and to stand sideways with their head facing the screen (mimicking the snowboarding stance, Figure 1). For the analysis of the results, the Overall Stability Index (OSI) was used.

The registered data was statistically analysed using STATISTICA (a data analysis software system), Version 10 by StatSoft, Inc. (2011). In order to establish the conformity of the analysed dispersion matrix to a normal distribution, the Shapiro–Wilk test was utilised. The statistical significance of the dependencies between all of the lateralisation parameters was then calculated

using the Spearman correlation coefficient. As to postural stability on the unstable Biodex platform, the significance of the determined differences after logarithmisation was checked using the analysis of variance (ANOVA) method. When statistically significant differences were reported, a post-hoc test was performed (Fisher's LSD test of the lowest significant differences). The evaluation of the differences in the static postural stability parameters (AMTI platform) and the torque values between the leading and the non-leading limb was performed using the non-parametric Mann-Whitney U test. For all the tests, the significance level was set at  $p < 0.05$ .

## Results

Among the surveyed snowboarders, the overwhelming majority (over 90%) declared themselves to be right-handed when throwing and right-footed when kicking a ball. These two parameters determine whether the person is considered right handed or left handed and right footed or left footed, respectively. Thus, these parameters decidedly correlate with each other (Table 1). Moreover analysis showed that 72% of the respondents bounced off the ground from their left lower limb and 28% from their right one when jumping forward on one leg combined with a running start. The data re-

Table 1. Laterality declared by the participants of the survey while performing certain everyday life and sports activities

Dominant side	One-handed throwing <sup>a</sup>	Kicking a ball <sup>a, b</sup>	Bouncing off the ground <sup>b, c</sup>	One-legged stance	Seeing with one eye	360° rotation jump <sup>c</sup>	Leading leg on a board
Left	8%	11%	72%	46%	42%	59%	34%
Right	92%	89%	28%	54%	58%	41%	66%

<sup>a</sup> statistically significant interdependency between one-handed throwing and kicking a ball; ( $p < 0.001$ ,  $r = 0.60$ )

<sup>b</sup> statistically significant reverse interdependency between kicking a ball and bouncing off the ground; ( $p < 0.001$ ,  $r = -0.35$ )

<sup>c</sup> statistically significant interdependency between bouncing off the ground and 360 rotation jump; ( $p = 0.003$ ,  $r = 0.29$ )

garding ball kicking and one-legged bouncing off the ground are the only ones to show a negative correlation. This observation indicates a proportionally inverse dependence, i.e. where people kick a ball with their right foot but bounce off the ground using their left limb, and vice versa. The statements concerning bouncing off the ground and aerial rotation correlated. However, no compelling relationship between the direction of the snowboarding stance and the other discussed lateralization parameters in everyday life was established. In the study group, 68% subjects said that they ride on snowboard with the right foot in front (in snowboarding known as the 'goofy' stance) and 32% with the left foot in front (known as the 'regular' stance).

As was to be expected, the majority of respondents were right-handed and right-footed; hence, analysis of the interdependency between the right/left lower limb positioned at the front of the snowboard and the lateralisation factors would have been unjustified (i.e. if we were to discuss the results in this way, the significant correlation would only exist in the case of people snowboarding with the right side to the front). Therefore, the interdependencies were not analysed in terms of the left/right axis, but instead with regard to the dominant side of the front/rear lower limb on the board plane while performing a given motion (Table 2). Assuming this approach to be the right one, no significant interdependencies were found between the dominant side while snowboarding and the lateralization parameters for the everyday human activities.

Moreover, static muscle torques were measured for the knee flexors and extensors and the ankle plantar flexors. Data for the left and right lower limbs was collected; however, in the course of a further comparative analysis the data was calculated only for the anterior/posterior position on the board (Figure 2). A closely corresponding set of values was calculated for each function, and these were not differentiated with regard to the muscle torque of the lower limb depending on the direction of the stance on the board.

In evaluating the measurement results of the one leg stance on the AMTI platform, the same division was utilized for the front/rear leg. Table 3 shows the values for the centre of pressure path length. Considerably higher ( $p < 0.001$ ) values of the parameters were reported when the test was performed with the subjects' eyes closed; but

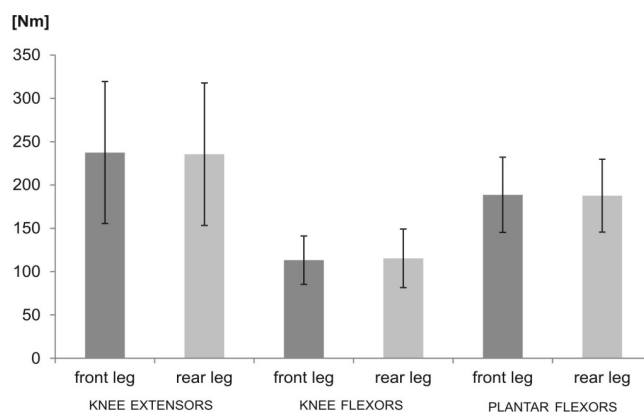
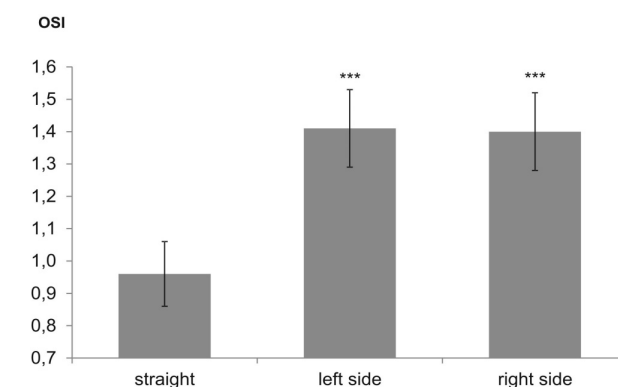


Figure 2. Mean  $\pm$  SD values of the muscle torques under static conditions for the knee flexors and extensors, and ankle plantar flexors of the front and rear lower limbs on the board



\*\*\* Values significantly higher ( $p < 0.001$ ) than in the neutral position

Figure 3. Mean  $\pm$  SD value of the overall stability index (OSI) in the neutral standing position heading front and with the left and right side to the front

Table 2. Interdependency between the leading leg on the board (the one at the front) and the declared laterality while performing other tasks

Leg on a board	One-handed throwing	Kicking a ball	Bouncing off the ground	One-legged stance	Looking with one eye open	360° rotation jump
Front	55%	55%	51%	60%	49%	57%
Rear	45%	45%	49%	40%	51%	43%

Table 3. Mean  $\pm$  SD values of the COP path length during the postural stability test on one leg on the AMTI platform in regard to the lower limb's position on the board – at the front and at the back

Protocol	Front leg	Rear leg
Eyes open	Path length (cm) 37.52 $\pm$ 11.95	36.01 $\pm$ 10.22
Eyes closed	Path length (cm) 101.48*** $\pm$ 35.17	105.18*** $\pm$ 44.80

\*\*\* values significantly higher ( $p < 0.001$ ) than with eyes open

no statistically significant differences in the postural stability parameters were found between the front and rear leading leg on the board.

The dynamic postural stability was evaluated using the Biodex Balance System platform. The subjects were given the task of keeping their balance on the dynamic platform with their eyes open while visually controlling the COP deviation on the biofeedback screen. The first testing protocol was performed in a neutral position – with the subject standing in front of the screen. The subsequent two protocols required the subjects to stand with either their right or left side to the front, while their face was directed at the screen, i.e. in a head position similar to the snowboarding stance. The overall stability index (OSI) values for all the trials are presented in Figure 3. It should be noted that the postural stability values obtained for lateral/directional stance are higher (and are statistically significant at  $p < 0.001$ ) than the values recorded in the neutral position.

## Discussion

Eighty seven out of 100 participants were characterised by right-sidedness, i.e. their right hand was dominant while performing manipulative motor activities and their right leg was dominant as the swinging limb when kicking a ball. 6% of the respondents were decidedly left-sided; while 5% showed signs of Type I cross-lateralisation (right handed/left footed). In the case of two subjects, Type II cross-lateralisation was established (left handed/right footed). The occurrence of these four basic laterality models within the hand-foot system established during this study corresponds to the data gathered for the overall European population by other authors [14, 18].

Based on the visuospatial study of laterality in volleyball players and rowers conducted by Giglia et al. [19], the researchers proved that differences between the right and left side are only present in the case of the top-notch professionals. However, the lateralization results gathered from ski carving turns by Vaverka and Vodickova [20] showed that when the preferred lower limb is also the outer leg, it affects efficacy of a turn. Their study of laterality during symmetrical ski turns showed that the functional preference of the lower limb can affect the execution of a turn, even in the case of professional skiers. Furthermore, Jandová and Charousek [21] performed an evaluation of ski runners and demonstrated that even for motions such as a two-step glide (V2 Alternate), which is symmetrical, the kick off will be performed quicker and in a shorter time by the dominant leg. The practical meaning of this is that when training, the ski runners should focus on improving their explosive power, especially in the case of the non-dominant leg.

Danielsson [11] analysed the lateralisation parameters among proficient snowboarders and compared the data with the results of people who did not train snowboard-

ing. He did not find any differences with regard to the ranges of motions within the main joints or the right and the left side. The only meaningful interdependencies were noted when he analysed the strength of the lower limbs and the hip circumference. The author highlighted the fact that the snowboarders he evaluated presented a higher muscle strength value in the leg placed toward the rear end of the board. This may be because the back leg functions as a support and is bounced off while performing most of the elements of snowboarding freestyle techniques.

Our study indicates the lack of a significant relationship between the selected parameters in regard to the declared laterality and the directionality of the stance while snowboarding. The muscle torque values under static conditions and the postural stability parameters also did not differentiate the limbs based on their position on the board. It is worth mentioning that the stability evaluation was performed on the participants who were experienced snowboarders taking part in an snowboard instructor course. Therefore, it may be assumed that the lack of a consequential difference in the stability results between the front limb and the rear limb results is a consequence of the riders' skills and their frequent shifting in stance direction while performing this sport. Executing freestyle elements of snowboarding and free-riding techniques often results in a forced bi-lateralisation, which could have affected the symmetry distribution of the stability factors. To verify this hypothesis, further studies will need to evaluate people who do not ride on regular basis and participants of a snowboarding course for beginners utilizing the same protocols as in the present study.

As a rule, in order to maintain the proper posture and posture control, the entire motor system is involved in the execution of a given task, which means that various groups of muscles undergo a concomitant strain [22, 23]. Snowboarding requires constant activity of these muscles under conditions of a relative dynamic stability and the learning process encompasses sets of exercises and activities aimed at increasing/improving the balance kinesiology while riding a snowboard. Physical exercises done under conditions where balance is disrupted result not only in the enhancement of postural stability, but also affect the muscles and build up strength. Myer et al. [24] indicated that a training protocol including balancing exercises is just as effective as plyometric training in terms of strengthening the muscles and overall fitness [25]. Similarly, Gorman et al. [26] and Lynn et al. [27] conducted separate experiments, and both demonstrated the multi-dimensional efficacy of training that included balancing exercises for the entire body and incorporated the muscle strength of the lower limbs, and not simply training that included only equilibrium components.

The present study has showed notable differences in the postural stability between a neutral standing posi-

tion and the same position but with head facing sideways (similar to the directional snowboarding stance). Nonetheless, the available literature does not provide sufficient accounts of studies that describe the stability parameters in the case of snowboarders, and which evaluate the effects of snowboarding courses on changes in the components of posture control.

## Conclusions

Considering the results of the study, the stance direction on the snowboard (i.e. declaring the so-called 'leading leg') is yet another completely independent functional laterality element. What is more, the lateral positioning on the board with the rider's face simultaneously turned toward the direction of the slide poses a considerable difficulty in keeping posture control. With this conclusion in mind, a further study is planned which would be specifically designed to evaluate the stability of the body in people who are just beginning their adventure with snowboarding. Such a study would also assess how this sort of training affects the postural stability parameters.

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*Correspondence address*

Michał Staniszewski  
Zakład Sportów Wodnych i Zimowych  
Akademia Wychowania Fizycznego  
Józef Piłsudskiego  
ul. Marymoncka 34  
00-968 Warszawa 45, Poland  
e-mail: [michal.staniszewski@awf.edu.pl](mailto:michal.staniszewski@awf.edu.pl)