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Static and Dynamic Balance and Injury Prevalence in Snowboard Instructors

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ABSTRACT

Background. Snowboarding is a quite popular winter sport, though associated with the risk of injury.

The aim. To determine the relationship between sport injuries and static and dynamic balance in snowboard instructors.

Methods. The study included snowboard instructors from Ontario, Canada. Questionnaires were given before and after the winter season to obtain injury history. Static balance was evaluated with a Wii Balance Board. Dynamic balance was evaluated using the Y balance test. The results were compared between different genders, age and days on-snow per season.

Results. Male snowboard instructors had, on average, higher static balance scores than the females. Both male and female scores for testing with eyes closed were significantly lower than with eyes open. The female snowboard instructors had, on average, higher dynamic balance scores than the males. However, for eyes closed testing, female snowboarders' scores were noticeably better than the males' scores. Nine of out twenty snowboard instructors had sustained one or more injuries in the past snowboarding season. One female and one male sustained two injuries each, and in total there were ten injuries amongst twenty snowboarders.

Conclusions. There was no significant difference between prevalence of injury and balance amongst different genders.

Keywords: snowboarding, sports injuries, static balance, dynamic balance.

INTRODUCTION

Snowboarding is a young sport, which has evolved rapidly during the last 30 to 40 years, with the first modern-style boards produced in the early 1970s and first showcased in the Winter Olympics at Nagano in 1998 (Vernillo, Pisoni, & Thiébat, 2018).

Snowboarding is associated with a relatively high rate of injuries, with sprains and fractures being the most common followed by contusions, lacerations, dislocations and concussion. The upper extremity is injured nearly twice as often in snowboarding than skiing, with approximately 50% of injuries involving this region, and fractures occur more than twice as often as in alpine skiers (Kim, Endres, Johnson, Ettlinger, & Shealy, 2012; Mirhadi, Ashwood, & Karagkevrekis, 2015). Wrist injuries, particularly fractures, are the most common snowboarding

injuries, while knee injuries are usually less severe, with one study reporting a complete ligament rupture in only 2 of 62 reported knee injuries (Helmig, Treme, & Richter, 2018). Beginners are at an increased risk of wrist injuries, mostly due to frequent falls, and experts tend to have more ankle injuries, often associated with freestyle maneuvers, and requiring medical attention (Ogawa, Sumi, H., Sumi, Y., & Shimizu, 2010). Research also shows that core training is a key component for stabilization which requires strong abdominals, spine, back extensors and quadratus lumborum musculature. This is now shown to be essential for optimal sports performance and injury prevention (Hébert-Losier & Holmberg, 2013). Balance and the prevalence of snowboard injuries has yet to be researched.

The aim: To determine the relationship between sport injuries and static and dynamic balance in snowboard instructors.

METHODS

Subjects. 20 snowboard instructors (10 men and 10 women) from different ski resorts in Ontario participated in this study. Over a season, they spent up to 130 days on snow, depending on whether they worked part-time or full-time. The subjects' anthropometric and age data are shown in Table 1.

Table 1. **Characteristic of participants**

Variable	Women (n=10)	Men (n=10)	Total
Age (y±SD)	26.90 ± 6.08	35.20 ± 15.48	31.05 ± 12.21
Height (cm ±SD)	168.80 ± 6.91	182.00 ± 7.38	175.40 ± 9.71
Weight (kg±SD)	64.70 ± 8.92	80.65 ± 9.08	72.67 ± 11.98

SD – standard deviation

Organization. All participants were informed of any risks associated with participation in the testing. Subjects were excluded if a current injury that limits the subject's ability to participate in testing as determined by a physiotherapist or athletic trainer is reported in a health history questionnaire, and/or a history of a concussion if allowed to participate. Injuries are defined as those causing athletes to miss 7 days or more before return to full participation. The athletes or their parents (if the snowboarders were minors) signed a written informed consent form, and the athletes participated in the study on a voluntary basis. The experimental procedures were explained to all the subjects, and a signed informed consent was obtained: the protocol was approved by the institutional research ethics committee.

All the subjects were handed a research information sheet and given the option to withdraw at any time from the study.

The subjects were all tested individually.

Questionnaire. At the beginning of the winter season (December/January), each participant completed a questionnaire providing baseline characteristics and information from the previous winter season, including work status, days on snow, previous time-loss injuries, and participation in conditioning programs. At the end of the ski season (after March 17th), the participants completed a questionnaire that addressed whether they had experienced a time-loss injury and days on snow.

Static balance. The Wii Balance Board (WBB)-based posturography system was used to measure static balance (Sato & Goh, 2021). This consisted of a WBB, a personal computer with Bluetooth, and custom software, Ross Clark – WBB Website Version. During the experiment, each subject was asked to stand quietly on the WBB for the following balance tests in order: double limb standing with eyes open and feet a comfortable distance apart (measured and kept consistent for both testing sessions), double limb standing with eyes closed and feet together, single limb standing (on each limb) with eyes open, and single limb standing with eyes closed. During each trial, the participants were instructed to keep their hands placed on their hips and to remain as still as possible for the duration of the trial. Data was collected for 15 s during single limb trials and for 30 s during double limb trials. A total of three successful trials (maximum of three unsuccessful attempts) were conducted for each task with 15 s of rest between trials and a minimum of 60 s between tasks. Center of pressure (COP) path length (PL) and COP velocity average (VA), and the mean of three repetitions were used for values of outcome measures.

Dynamic balance. The Y Balance Test (YBT) was used to measure dynamic balance (Coughlan et al., 2012). The YBT examines maximum lower extremity reach of the free leg in the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions while the subject maintains a unilateral stance with the opposite leg centered on a platform. This process is repeated after the subject switches to the contralateral leg. According to standardized protocol, a trial is considered invalid if the subject (1) fails to maintain unilateral stance, (2) touches down on the reaching foot, (3) fails to return to the starting position, such as removing the hands from the hips, or (4) pushes or kicks the indicator to increase distance. To measure lower limb length, the subject laid in supine, a mark was placed with a fine-tipped marker on the subject's most inferior aspect of each anterior superior iliac spine and on the most distal portion of each lateral malleolus. After the player lifted their hips off the table, the examiner passively straightened the legs to equalize the pelvis. The subject's right and left limb length was then measured from the

anterior superior iliac spine to the most distal portion of the lateral malleolus with a cloth tape measure.

Participants watched an instructional video that explained and demonstrated the testing procedures. Participants then removed their shoes and socks and placed the most distal end of the longest toe of the right stance leg at the green line on the platform. The participant got four to six practice trials performed in the ANT, PM and lastly, PL. The participant switched to the left foot on the platform after performing on the right foot every time before repeating again for the next direction. After completing the practice trials, three trials were repeated for each direction, in which the examiner recorded the maximum reach score. Differences in the maximum reach distance in centimeters for each limb were compared to examine right and left asymmetry for each ANT, PM, and PL direction.

The normalized composite score (CS) was calculated by summing the maximum reach in each of the 3 directions, then dividing by 3 times the leg length for that side. Leg length was measured from the inferior tip of the anterior superior iliac spine to the distal end of the medial malleolus for both legs.

$$\textbf{Normalized Composite Score (CS)} = \frac{(\text{Anterior} + \text{Posteromedial} + \text{Posterolateral})}{\text{Leg Length} \times 3} \times 100$$

Statistical Analyses. Data was tested for normality. Normally distributed data was analyzed using paired samples t-test and Analysis of Variance (ANOVA). The significance value was set a $p<0.05$, the confidence interval was set at 95%. The relationship between prevalence of injuries, static balance scores and dynamic balance scores were determined using the Spearman rank correlation. Descriptive statistics was presented in tables or graphs as number or percentages, as well as mean, standard deviation. All data were analyzed using SPSS for Windows, Version 13.0 (SPSS Inc, Chicago, IL). T-tests were conducted to show comparisons between all the snowboarders' static and dynamic balance.

RESULTS

Figures 1and 2 show the descriptive data of the subjects, snowboard instructors, with mean ± standard deviation. The results of one-way variance analysis showed that the static and dynamic balance among genders, age and experience have no meaningful differences. No results were significant.

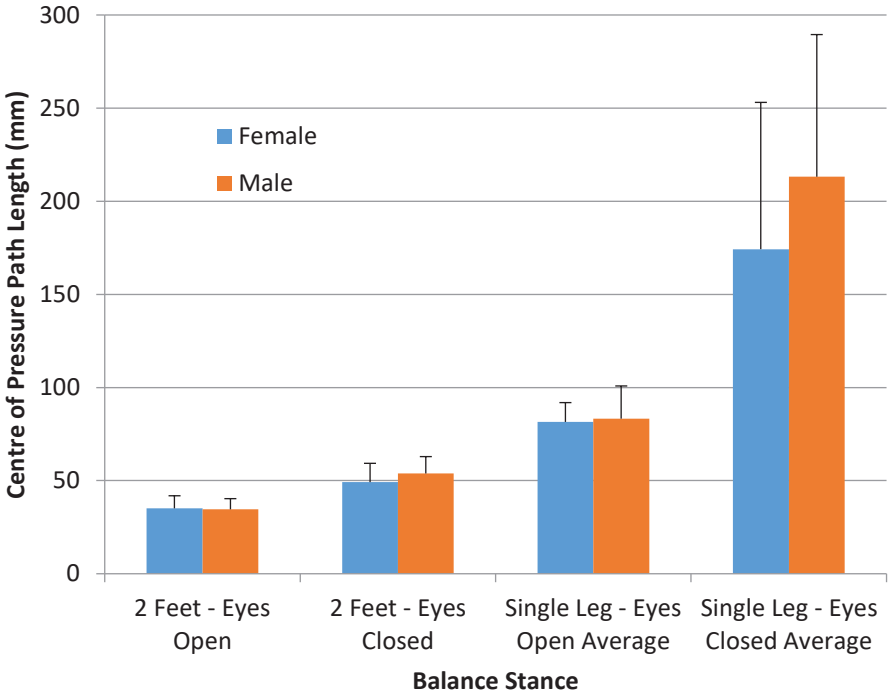

Fig. 1**. Mean, Standards deviation of center of pressure path length for static balance testing of all snowboarders**

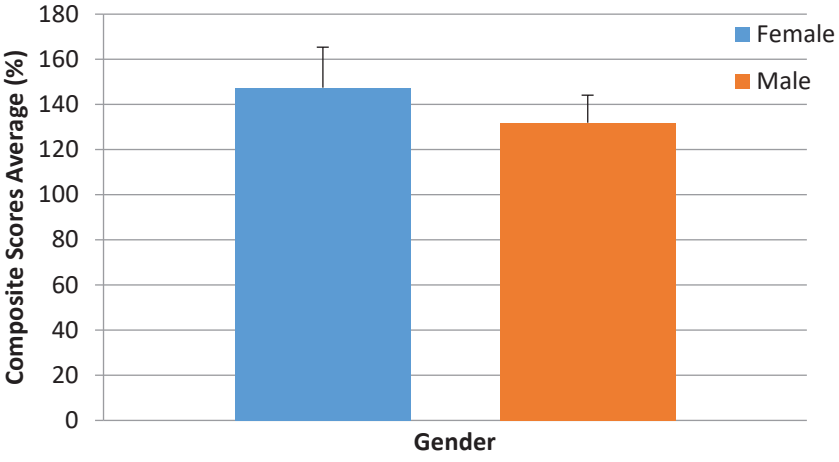

Fig. 2**. Mean, standard deviation of composite scores for dynamic balance standing of all snowboarders**

Table 2 shows the body parts most frequently injured during the season which included the knee, low back and hip. Notably, due to the study's exclusion of participants not allowed to have any past concussions, there were no head/face injuries.

Table 2. **Descriptive for questionnaire responses regarding injury history**

Descriptive for research study responses

		Frequency	Percent
1.2 Was the injury during:	Free time	4	20
	Work	7	35
		9	45
1.3 Injured side:	Left	6	30
	Not applicable	2	10
	Right	3	15
1.4 Injury severity (time taken to return to physical activity)	Mild (4-7 days)	4	20
	Minimal (2-3 days)	2	10
	Moderate (8-28 days)	3	15
	Severe (>23 days)	2	10
1.5 Injured body part:	Forearm	1	5
	Hip/groin	2	10
	Knee	3	15
	Low back	2	10
	Lower leg/achilles	1	5
	Thigh (front)	1	5
	wrist	1	5
1.6 Type of injury:		3	15
	Contusion/bruise	5	25
	Fracture	1	5
	Lesion of meniscus, cartilage or disc	1	5
	Muscle rupture/strain/tear	7	35
	Nerve injury	2	10
	Tendon injury/tendinopathy/bursitis	1	5
1.7 Was the injury due to:		9	45
	Overuse	4	20
	Trauma	7	35
1.8 Was the injury caused by contact?		9	45
	No	4	20
	Yes	7	35

The comparison between characteristics such as age, and the number of injuries this season, was insignificant, as well as the comparison between number of on-snow days and number of injuries this season. Though the top 5 subjects with the most on-snow subjects all had the most injuries (i.e., 78–105 on-snow days each 1 injury versus 122 on-snow days had 2 injuries).

Static Balance

The comparison in Figure 3 between the normalized reach distances and the direction of reach amongst females and males was insignificant.

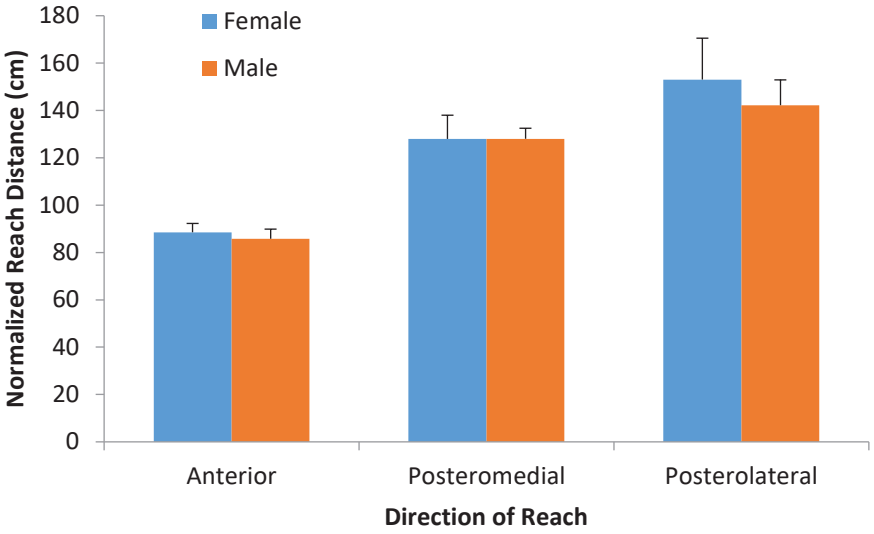

Figure 3**. Normalized reach distances versus direction of reach amongst female and male snowboarders**

In Figure 4, the comparison between center of pressure path length versus different stances among both genders was insignificant ($p>0, 0.5$).

Figure 5 shows the comparison between the center of pressure path length versus individual left and right female individual leg stance with eyes open and closed was insignificant.

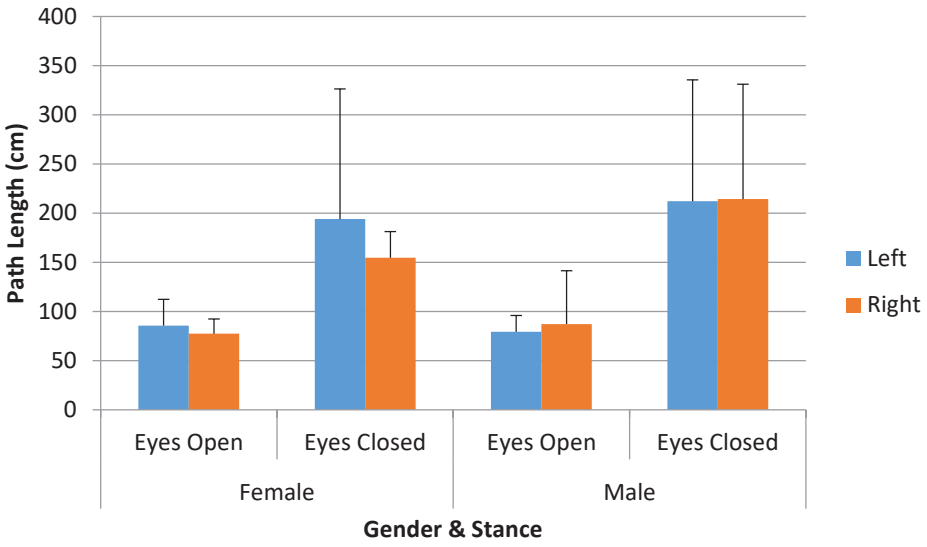

Figure 4. **Center of pressure path length versus left and right leg balancing in different stances during static balance among female and male snowboarders**

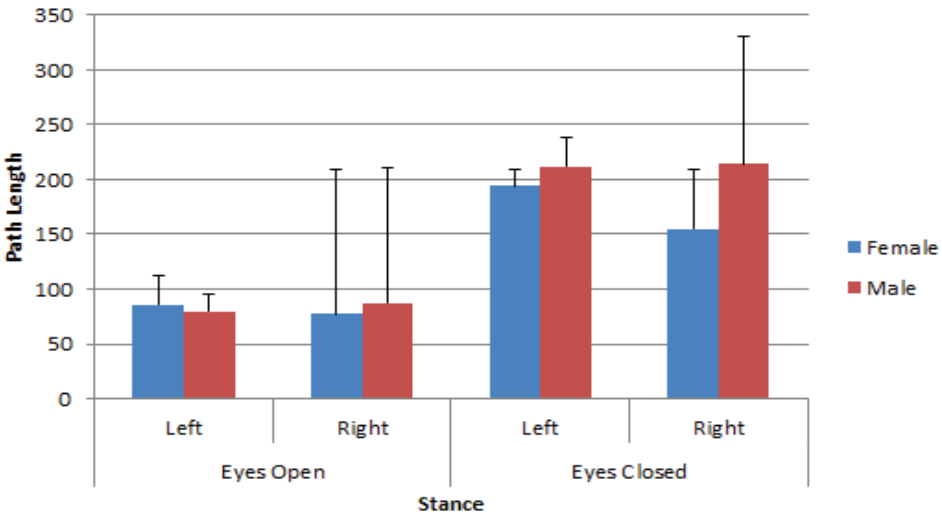

Figure 5. **Center of pressure path length (cm) versus individual left and right female and male single leg stance with eyes open and closed**

Dynamic Balance

The comparison between the composite score from the Y Balance Test (YBT) and the number of injuries this season was insignificant. According to the trend line, it would seem that the higher the composite score, the higher occurrence of injury, which is not significant. Age compared with the composite scores was insignificant.

DISCUSSION

The aim of the study was to measure static and dynamic balance and determine injury prevalence in snowboard instructors and find the relationship between these. We found that male snowboard instructors had, on average, higher static balance scores than the females. Both male and female scores for testing with eyes closed were significantly lower than with eyes open. The female snowboard instructors had, on average, higher dynamic balance scores than the males. However, for eyes closed testing, female snowboarders' scores were noticeably better than the males' scores. Nine out of twenty snowboard instructors had sustained one or more injuries during the last snowboarding season. One female and one male each sustained two injuries each, and in total there were ten injuries amongst twenty snowboarders. Studies state that poor static balance is a risk factor for non-contact anterior cruciate ligament injury (Oshima et al., 2018).

To date, no study has empirically investigated the factors that cause snowboard injuries, aside from the occurrence of falls. For this study's purpose, a closer look was taken to determine the relationship between static and dynamic balance and if that subsequently affected injury prevalence.

A surprising result was found where snowboard instructors' characteristics as well as static and dynamic balance had no significant effect on injury prevalence. This is contradictory to past studies (Plisky et al., 2006; McGuine & Keene, 2006), which found that basketball players with poor balance were more susceptible to ankle injury and also found that higher postural sway scores correlated with more severe ankle injury.

Static and dynamic balance test scores were compared with injuries this season and none of the predictors was significant enough to affect the prevalence or risk of injuries in the snowboard instructors. The only comparison that seemed remotely close to being significant was of males versus females for right leg eyes closed measurement for static balance testing. The females had a 60 cm COP path length difference compared with the males.

There were a few positive correlations that, while not significant, still showed a positive correlation, which was between the top 5 subjects with the most on-snow days and increased number of injuries. This could be due to an extended amount of time and more chances to get injured, where 122 days of on-snow days with 3 injuries is 12 times the number of days compared with the snowboard instructor who was only on snow for 10 days this past season and had no injuries.

The study reported a few possible theories for the injury prevalence which included underreporting of injuries, method of collecting injury data, and misdiagnosing. Also, due to the nature of the sport, when concluding balance test scores, flexibility, strength, or other anatomical concerns, along with the concussion history should be considered as underlying risk factors. It may be possible that ankle range of motion or quadriceps strength were underlying risk factors that presented in the YBT and static balance testing. Because this study did not measure these factors, we cannot make sure which factors most influence the results of the balance tests.

The injury pattern is different from recreational athletes, with a greater share of knee injuries and fewer wrist injuries (Torjussen & Bahr, 2006). More than half of the injuries occurred while at work and were due to trauma, most likely from a fall, because of the mentioned injury caused by contact. The most frequent type of injury was a muscular strain, tear or rupture. However, considering the injury severity was mostly mild and minimal, the injury would most likely be a muscle strain, since tears and ruptures would require at least 12 weeks of recovery and may require surgery; while a strain can heal pretty quickly with adequate rest (Askling, Saartok, & Thorstensson, 2006).

Since there was a relatively small number of subjects and injuries, there might have been a possible bias where the subjects may not have stated all their injuries, where they only remembered the more severe ones and therefore amplifying the injury severity. Due to the study needing to look at past history, the recall bias should be mentioned as well. Many concussions go undiagnosed, because athletes often fail to report concussive symptoms or are not accurately identified as having concussive symptoms (Marar et al., 2012). Concussed subjects, following the healthy subjects' controls, revealed decreased postural stability compared with their own baseline scores and to their matched controls during the initial 3 days after injury. The degree of balance impairment in the concussed subjects increased with increasing task demands, such as altering the visual, vestibular, or somatosensory feedback during the trial (Guskiewicz, 2011). Therefore, if a subject had an undiagnosed concussion and/or it was never treated, this could affect their balance as well. Professional snowboarders may also underestimate their actual impairment, as their career is not over yet and like many athletes and the general population,

people do not rest or go to physiotherapy unless it is an injury that will not go away after a few weeks since it happened, thinking that it will heal on its own.

Some other factors that could have been measured include snowboarding style (leading leg), in order to distinguish any differences in between the legs themselves (muscle strength, ROM, etc.) aside from just balance testing, any other sport involvement that could have led to injuries as well as type of riding style (Murphy, Connolly & Beynnon, 2003).

Also, if ski resorts implemented a pre-season conditioning program or testing, for future research it would be very beneficial as well as the snowboard instructors would be educated on injury prevention and working in a safe environment. Research shows that core training is a key component for stabilization which requires strong abdominals, spine, back extensors and quadratus lumborum musculature. This is now shown to be essential for optimal sports performance and injury prevention (Hébert-Losier & Holmberg, 2013; Platzer et al., 2009; Shubert, 2011).

Furthermore, the Wii Balance Board has been used in stroke patient rehabilitation and with some good results where Wii-based virtual reality exercises resulted in a significant improvement in dynamic balance (Karasu & Batur, 2018). Therefore, the Wii Balance Board is helpful in testing as well as for rehabilitation programs for improving balance and potentially reducing number of falls in the elderly population and in the hopes for snowboarders, the Wii could then be further used for training and prevention of future injuries.

CONCLUSIONS

Results showed that as the number of on-snow days increases, so does the number of injuries; the higher the dynamic balance composite score, the higher occurrence of injury; and the younger the snowboarder, the higher the composite score. There was no significant difference between prevalence of injury and balance amongst different genders.

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Disclosure of interests – none.

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Snieglenčių instruktorių statinė bei dinaminė pusiausvyra ir traumų paplitimas

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SANTRAUKA

Tyrimo pagrindimas. Snieglenčių sportas gana populiari žiemos sporto šaka, tačiau labai susijusi su traumų rizika.

Tikslas – nustatyti sąsajas tarp snieglenčių sporto instruktorių sportinių traumų bei statinės ir dinaminės pusiausvyros.

Metodai. Tyrime dalyvavo 20 snieglenčių instruktorių (10 vyrų ir 10 moterų) iš Ontarijo, Kanados. Anketos buvo pateiktos prieš žiemos sezoną ir po jo, siekiant sužinoti traumų istoriją. Statinė pusiausvyra buvo vertinta naudojant *Wii Balance Board*. Dinaminė pusiausvyra buvo vertintas naudojant Y pusiausvyros testą. Rezultatai buvo lyginami tarp skirtingų lyčių, amžiaus ir dienų praleistų ant sniego skaičiaus per sezoną.

Rezultatai. Snieglenčių instruktorių vyrų statinė pusiausvyra buvo geresnė nei moterų. Tiek vyrų, tiek moterų statinė pusiausvyra užsimerkus buvo reikšmingai prastesnė nei atsimerkus. Snieglenčių instruktorių moterų dinaminė pusiausvyra buvo geresnė nei vyrų. Be to, užsimerkus snieglenčių instruktorių moterų pusiausvyra buvo žymiai geresnė nei vyrų. 9 iš 20 snieglenčių instruktorių patyrė vieną arba daugiau traumų per sezoną. Viena moteris ir vienas vyras turėjo po dvi traumas, iš viso buvo patirta 10 traumų. Tarp praėjusio sezono snieglenčių instruktorių traumų ir šio sezono traumų nebuvo nustatyta jokio ryšio. Rezultatai parodė, kad didėjant dienų praleistų ant sniego skaičiui, didėja traumų skaičius. Kuo didesnis dinaminės pusiausvyros balas, tuo didesnis traumos atvejis, o kuo jaunesnis sportininkas, tuo didesnis jo kompozicinis balas. Nėra reikšmingo skirtumo tarp traumų paplitimo ir pusiausvyros tarp skirtingų lyčių.

Išvados. Nenustatyta reikšmingų skirtumų tarp traumų paplitimo ir pusiausvyros tarp skirtingų lyčių.

Raktažodžiai: sportinės traumos, statinė pusiausvyra, dinaminė pusiausvyra.

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