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INJURIES IN THE PAMPOROVO AND BOROVETS SKI AREAS DURING THE 2019-2020 SEASON

OZLJEDE NA SKIJAŠTIMA PAMPOROVO I BOROVETS U SEZONI 2019. – 2020.

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SUMMARY

In Bulgaria, while a sub-regulation of the Tourism Law addresses the safety and security of ski slope users, insufficient attention is given to understanding the causes of accidents, gathering feedback, and implementing injury prevention strategies for snow sports. This study aims to analyze the types of accidents and injuries reported at the Borovetz and Pamporovo ski zones during the 2019/2020 season. Various factors were considered, including the time of injury occurrence, slope difficulty, type of injury, and type of ski or snowboard equipment used. Methods that were used were frequency analysis, document analysis, and comparative analysis. Injuries were categorized into four groups: head, torso, legs, and arms. The highest number of injuries involved the legs, followed by the arms. Knee injuries were the most common type of trauma on the slopes, followed by shoulder and lower leg injuries. Among all injuries, fractures were identified as the most severe, with lower leg and collarbone fractures being the most frequently reported. The peak occurrence of severe injuries was after 12:00 PM in both ski areas. This trend can be attributed to deteriorating slope conditions due to weather factors such as sun, wind, and positive temperatures, as well as increased slope usage by other snow sports enthusiasts.

Keywords: ski injury prevention, traumas, snow safety

SAŽETAK

U Bugarskoj, iako podzakonski akt Zakona o turizmu regulira sigurnost korisnika skijaških staza, nedovoljno se pažnje posvećuje razumijevanju uzroka nesreća, prikupljanju povratnih informacija i provođenju strategija za prevenciju ozljeda u zimskim sportovima. Ova studija ima za cilj analizirati vrste nesreća i ozljeda prijavljenih u skijaškim zonama Borovec i Pamporovo tijekom sezone 2019./2020. godine. Razmatrani su različiti čimbenici, uključujući vrijeme nastanka ozljede, težina skijaške staze, vrstu ozljede i vrstu skijaške ili snowboard opreme.

Ozljede su kategorizirane u četiri skupine: glava, torzo, noge i ruke. Najveći broj ozljeda zabilježen je na donjim ekstremitetima, a slijede ozljede ruku. Najčešće ozljede na skijaškim stazama bile su ozljede koljena, zatim ramena i potkoljenice. Među svim ozljedama, prijelomi su identificirani kao najozbiljniji, pri čemu su prijelomi potkoljenice i ključne kosti najčešće prijavljeni. Najveći broj teških ozljeda dogodio se nakon podneva u obje skijaške zone. Ovaj trend može se pripisati pogoršanju stanja skijaških staza uslijed vremenskih čimbenika kao što su sunce, vjetar i pozitivne temperature, kao i povećanom broju korisnika skijaških staza od strane drugih zaljubljenika u zimske sportove.

Ključne riječi: prevencija skijaških ozljeda, traume, sigurnost na ski stazi.

INTRODUCTION

The issue of accidents on ski slopes in Bulgaria and the identification of injury types is becoming increasingly relevant, as injury rates are high worldwide[3,5]. The number of visitors to ski areas is steadily increasing, while the expansion, modernization, and safety of the slopes have not yet reached the required standards. Despite existing regulations concerning information security on ski slopes and the classification of slope difficulty, many safety and security-related questions still need to be addressed through legislation. For example, there is currently no enforcement of compliance with existing laws, and the collection of data on the number of visitors to ski areas, as well as the number and types of incidents, remains unregulated.

The available information regarding the causes of accidents (e.g., collisions, falls), the type of sport practiced (e.g., skiing, snowboarding, telemark skiing), and whether the injured person is a ski school student or an independent practitioner is also incomplete[13,21]. Safety should be a top priority regardless of the type of equipment used or whether the activity takes place on or off regulated slopes[4]. Safety rules must be followed universally, and wearing a helmet has become an essential part of equipment for most skiers[17]. However, some researchers caution about the limitations of helmets in preventing injuries[16,18].

According to French statistics[9], the most common injuries diagnosed in skiers in France during the 2019/2020 season were knee injuries, with 32 percent being knee sprains, and the anterior cruciate ligament (ACL) being the most frequently injured. Published papers[4,6] and online statistics[10,11,12] also indicate that lower extremities are at a high risk of injury in skiing, with over 50 percent of all ski-related injuries affecting the lower extremities. The Ministry of Tourism's website offers just basic information, such as the number, length, and degree of difficulty of categorized slopes for the resorts of Borovets and Pamporovo. The only detailed and reliable data available regarding the number and type of incidents occurring in Bulgarian ski resorts were obtained from the Bulgarian Red Cross (BRC) and, more specifically, from the Bulgarian Mountain Rescue Service[1] which we reported to some extent previously[19]. This source provided the most comprehensive overview of ski-related injuries and accidents, making it invaluable for analyzing safety trends in Bulgarian ski areas. However, for the purposes of this study, we focused on comparing only the number and type of incidents at these two specific ski areas for several important reasons:

Comparable Slope Length: Borovets and Pamporovo have roughly the same total length of ski slopes, which allows for a more balanced comparison of incident rates. This similarity in total slope length ensures that differences in the number of incidents can be more confidently attributed to other factors such as skier behavior or slope design rather than to differences in the sheer size of the resort.

Historical Significance: Both Borovets and Pamporovo are the oldest and most well-established ski resorts in Bulgaria. As such, they attract a steady and diverse influx of visitors every year, ranging from beginners to experienced skiers. This makes them ideal candidates for studying long-term trends in ski-related accidents and for understanding how changes in resort management or safety practices impact overall incident rates over time.

Distinct Slope Configuration: Despite having similar total slope lengths, the two areas are radically different in terms of configuration, terrain characteristics, and the general nature of the slopes. Borovets is known for its steeper and more challenging runs, which cater to more advanced skiers, while Pamporovo is characterized by its gentler and more beginner-friendly slopes. Additionally, the altitude and topography of these two resorts vary greatly, which could influence the type and severity of accidents that occur. This variability allows for a nuanced comparison of how different environmental factors affect safety.

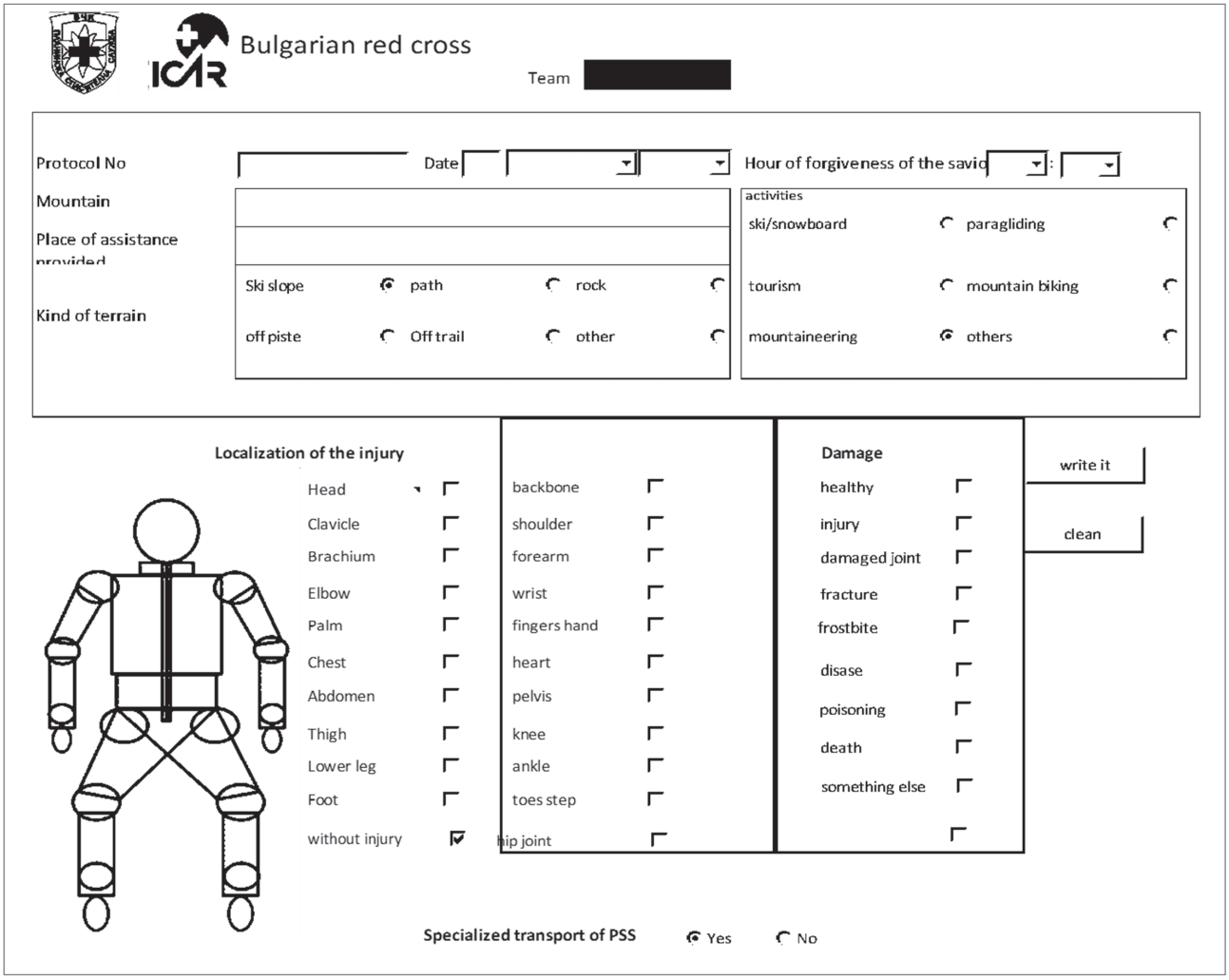
Accessibility Differences: The two resorts also differ significantly in terms of their proximity and access from major settlements and towns in Bulgaria. Borovets is closer to Sofia, making it more accessible to a larger population, while Pamporovo is situated further south, attracting a different demographic of visitors. These differences in accessibility could influence the volume of skiers and their skiing experience levels, which, in turn, might impact the type and frequency of incidents reported.

Given these factors, the methodology employed by the Bulgarian Mountain Rescue Service (PSS, Table 1) for incident registration and reporting was strictly followed when describing and comparing the incidents at these two resorts. This methodology ensures consistency in data collection and allows for an objective comparison of incident patterns between Borovets and Pamporovo. By adhering to this standardized approach, we can draw more reliable conclusions about the safety conditions in these two prominent ski areas.

The season 2019/2020 was chosen as it was the last season before the Covid pandemic crisis. In the next stage of the study, we intend to compare this period with the period after the recovery from the COVID crisis. The aim was to compare the type of accidents and injuries in the Pamporovo ski area and Borovets ski area for 2019/2020 (ski season) according to various characteristics: time of the injury, complexity of the terrain, type of injury, and gender, so the main goals were to perform:

- comparative analysis of incidents in the Pamporovo ski and Borovets ski areas, according to the complexity and length of the ski slopes.
- analysis of incidents by gender, degree of severity, type of injury (especially fractures).
- systematization of the incidents according to the complexity of the ski slopes and the time range of occurrence of the incidents.

Table 1. Mountain Rescue Service Incident Report example
Tablica 1. Izvještaj o incidentu Gorske službe spašavanja-primjer



METHODS

The data selected for analysis ranged from December 2019 to March 2020. During this period, 344 incidents in Pamporovo and 455 incidents in the Borovets ski area, where first aid was provided by the Mountain Rescue Service, were recorded. In the survey, we compared the ski areas based on the type, frequency, time of occurrence, and difficulty level of the ski slopes. The analysis identified when and on which ski slopes the most severe injuries, such as fractures, and the highest number of accidents occurred.

RESULTS AND DISCUSSION

Description of ski area Borovets:

Borovets is the oldest winter resort in Bulgaria, and it has modernized infrastructure from the mid-1980s. The resort is divided into two parts - a high and a low, connected by a cable car. The high part of the resort is between 2560 and 2000 meters above sea level, with an alpine character, and the lower part is situated between 2000 and 1300 meters above sea level in the forest belt. The resort also offers night skiing in the lower part of 4137 meters of ski slopes. The Borovets resort is located seventy kilometers from the capital, Sofia, with a population of about 2 million. It is near the city of Samokov, which has a population of 25 thousand people. The elevation in the area is 1260 meters. The total length of slopes in Borovets - 28.54 km, of which: Green - 8025 meters. (28%); blue-4.23 km. (15%); red- 13.02 km. (46%); black - 3.18 km (11%);

Description of Pamporovo ski area:

The resort of Pamporovo is also one of the old resorts in Bulgaria. The infrastructure has been renovated since the end of the 70s and the last century, after 2010. The resort is built in the Rhodope Mountains, located in the southern part of the country, and characterized by hilly terrain. The ski area is entirely in the forested part of the mountain, with

the highest part being Mount Snezhanaka - 1926 meters. The ski area is accessible from 4 entry points at about 1470 meters. The altitude difference in the resort is 570 meters. Pamporovo is on the territory of Smolyan, with a population of 33,600 people, and 80 km from Plovdiv, with a population of 370,000.The total length of slopes in Pamporovo is 30 km, of which green is 4.57 km (15%). blue-13.69 km. (46%); red-6.45 km. (21%); black-5.56 km. (18%);

From these data, we observe that 44% of the slopes in the Borovets resort fall into the easy and medium categories, while 57% are classified as difficult. Additionally, 14% of the slopes in this resort are used for night skiing. In the Pamporovo resort, 60% of the slopes are categorized as medium and easy, whereas 40% are classified as difficult. This distribution might explain the higher number of incidents in Borovets (Figure 1)

As shown in Figure 1, the Bansko ski area recorded the highest number of incidents during the study period. However, it differs significantly from the two analyzed resorts, Borovets and Pamporovo, as it is a much larger ski area where not all slope kilometers are officially listed. Bansko offers many "off-slope" and freeride skiing possibilities, which can also result in injuries. In regard to the two resorts of our primary interest, the Borovets ski area had 455 incidents, while the Pamporovo ski area had fewer, with only 334 incidents reported on the ski slopes, according to data from the Mountain Rescue Service (PSS). When the results are compared in relation to slope length, Bansko still shows a much higher incident rate: Bansko - 43.26 incidents/km; Borovets - 15.68 incidents/km; Pamporovo - 11.13 incidents/km; and Vitosha - 10.04 incidents/km.

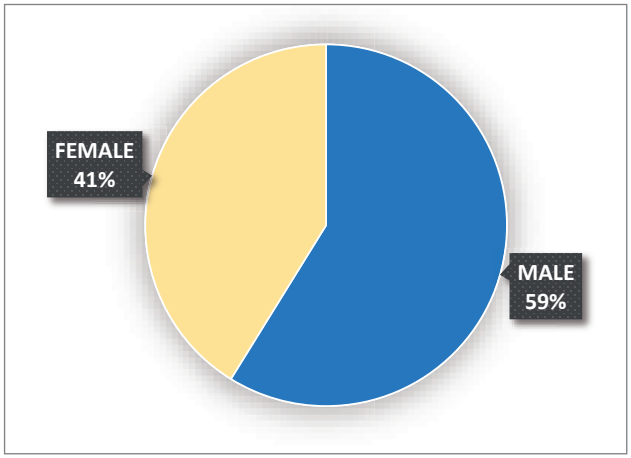


Figure 2. Distribution of incidents by sex.
Slika 2. Distribucija incidenata prema spolu.

The higher number of injuries were those where the victims were male, but it is very hard to interpret that as we are not sure about the sex proportions of total skiers on slopes in hat period.

The next data of interest were those pertaining to the time with the highest occurrence of incidents (Figure 3) .

Incidents peak between 13:00 and 14:00 in the afternoon but generally increase significantly after 11:00 am.

The peak of incidents in Pamporovo is between 2:00 and 3:00pm and again, we notice a significant increase after 11:00 am (Fig 4).

In both resorts, injuries increase with a clear trend after 11:00, while in Borovets, the peak is one hour earlier.

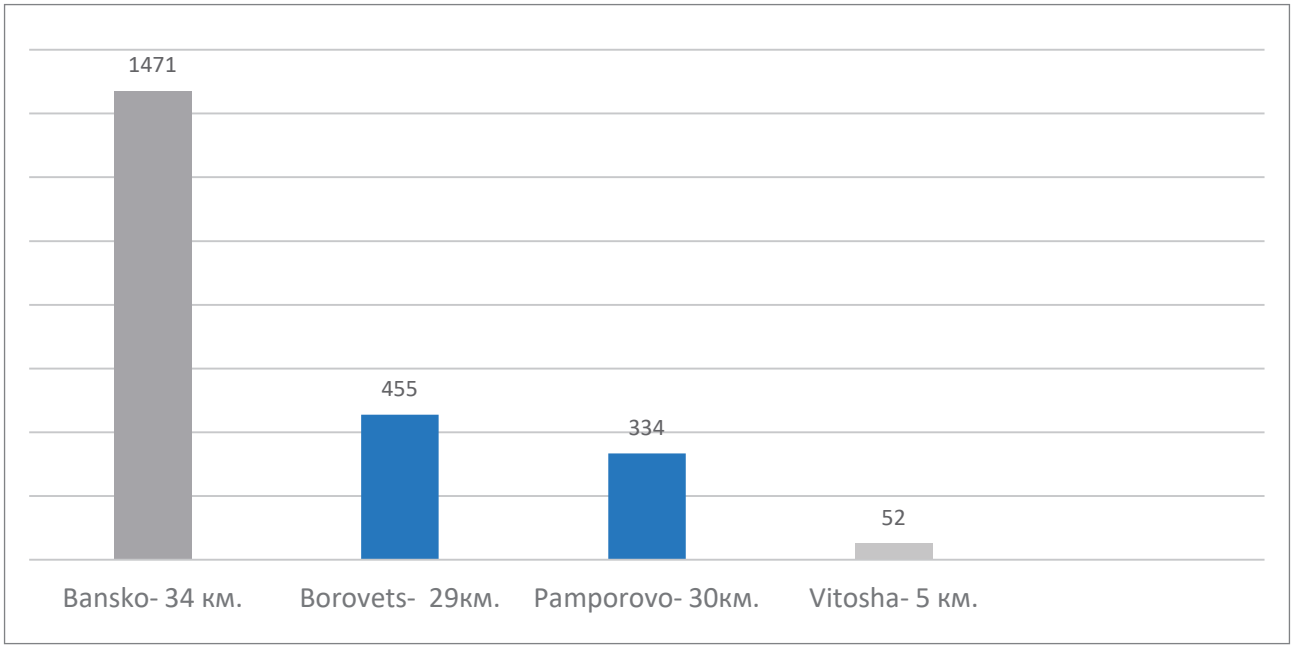


Figure 1. Number of incidents on ski slopes in Bulgaria for the 2019/2020 season (in this graph the data about Bansko and Vitosha were also included, even though they were not analyzed later) .
Slika 1. Broj incidenata na skijaškim stazama u Bugarskoj za sezonu 2019/2020 (U ovom grafikonu su također uključeni podaci o Banskom i Vitoshi, iako nisu kasnije analizirani.)

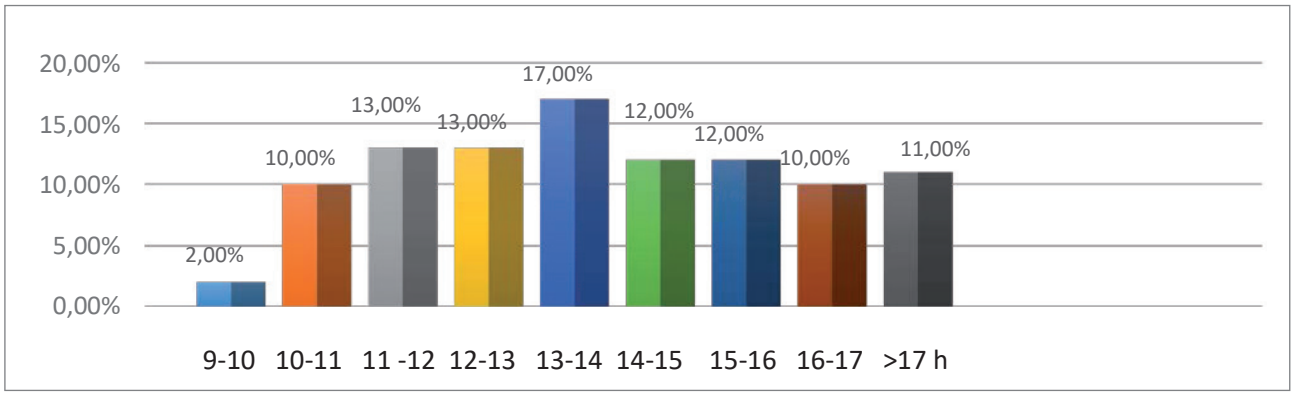


Figure 3. Number of incidents during the opening hours of the Borovets ski area.
Slika 3. Broj incidenata tijekom radnog vremena skijališta Borovets prema satima.

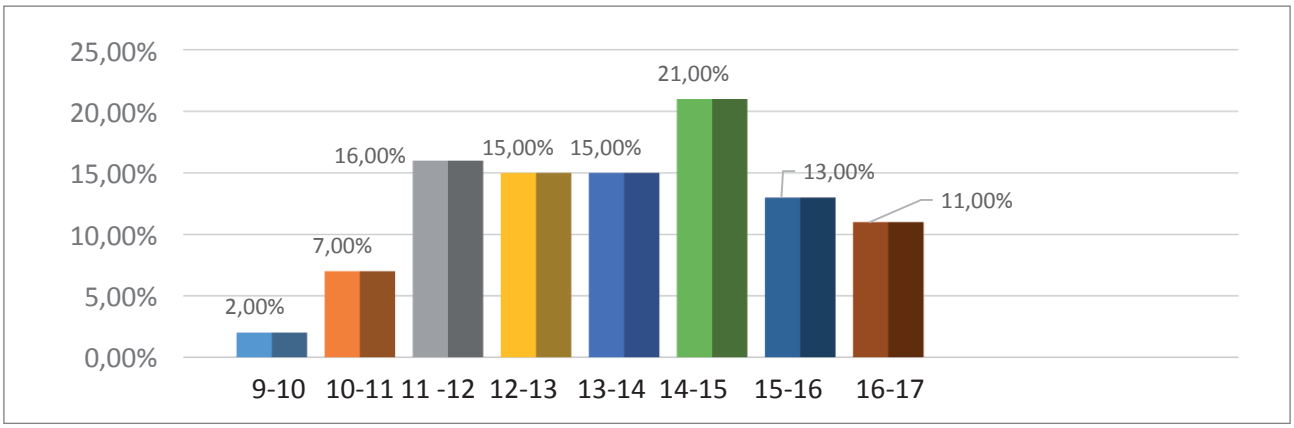
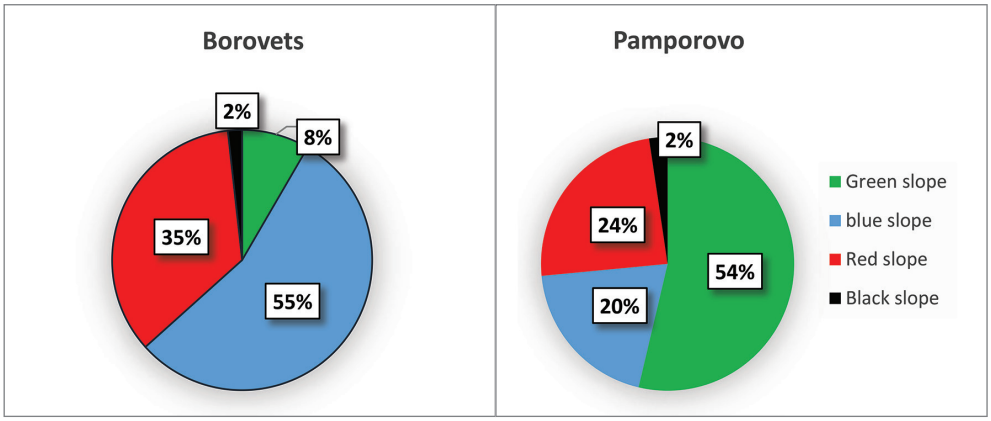


Figure 4. Number of incidents during the working hours of the Pamporovo ski area.
Slika 4. Broj incidenata tijekom radnog vremena skijališta Pamporovo.

The reason is accumulated fatigue. We assume that fatigue occurs earlier due to the complex alpine topography of Borovets and the more significant elevation difference. Another feature of the Borovets resort that explains the higher incidents is night riding and longer working hours. Considering that the area for night skiing is 14% of the entire territory, we believe the percentage of accidents during late skiing (11% of total) is not insignificant and should be given a special attention.

In the Borovets resort, the highest concentration of incidents was on easy blue slopes (55%), with the most of them being the “Martinovi baraki-1” slope (blue slope)



Figures 5 and 6. Percentage of incidents Borovets and Pamporovo according to the slope difficulty
Slike 5 i 6. Udio incidenata Borovets i Pamporovo prema težini staze

with 107 incidents (23%), followed by slope "Markujik-1" (blue) with 64 incidents. The "Martinovi baraki-1" slope is the main connection for five more ski slopes, but it is also used for night skiing from 18:00 to 22:00.

In the Pamporovo resort, 54% of incidents occur on green slopes, also very easy slopes. The highest number of incidents was found on the "Ski Path Pamporovo" slope (green slope), where 35% of the total number occurred. Although easy, this slope is a connecting artery to most of the slopes in the resort. In conclusion, more than 74% of accidents in both resorts happen on easier slopes - fairways or greens.

Figures 7 and 8 show the injury rates from accidents, with joint injuries accounting for the highest percentage. The number of injuries with fractures in Pamporovo was alarmingly high, over 30%.

In regard to the location, the highest number of injuries that required immediate Mountain Service further help were head injuries in both ski areas. Figure 9 and Figure 10 show the distribution of injuries.

In cases of head injuries, concussions were the most serious and the most common type. Concussion is a very common injury in racers as well[14], but usually not caused by the same mechanism as in our study, In our opinion, the primary reason for the high number of head injuries is the low helmet usage rate. This is particularly concerning, as head injuries are usually the leading cause of fatalities in skiing[7,20]. Some have shown a decrease in fatalities with the increase in helmet use over the last few decades[15]. However, other reports indicate that there has not been a corresponding decrease in severe head injuries, despite the rise in helmet usage[2] . In Bulgaria, helmet use is not mandatory, and a large number of skiers continue to ski without one.

When analyzing only joint injuries (Fig 11 and Fig 12), knee and shoulder joint injuries were found to be the most common.

Among all types of accidents that occur in snow sports, joint injuries are the most prevalent form of trauma

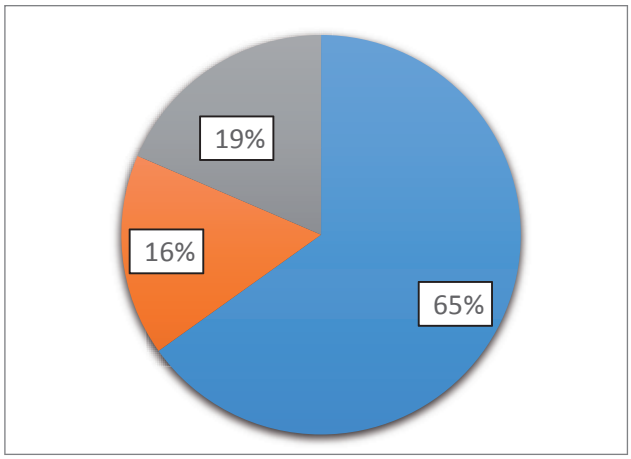


Figure 7. Types of injuries Borovets.
Slika 7. Vrste ozljeda Borovets.

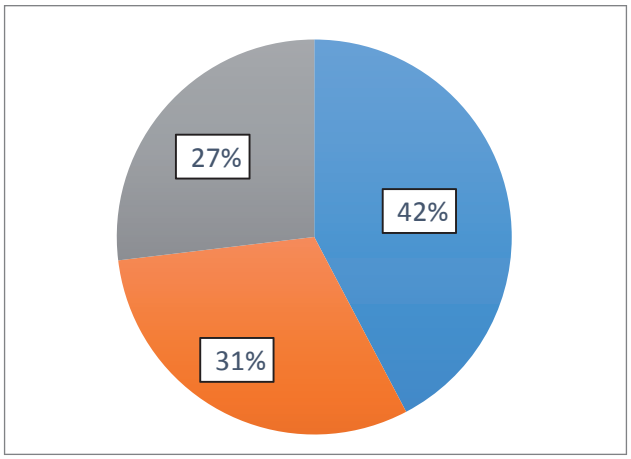


Figure 8. Types of injuries Pamporovo.
Slika 8. Vrste ozljeda Pamporovo.

*blue: joint injuries; orange - fractures; grey - other injuries

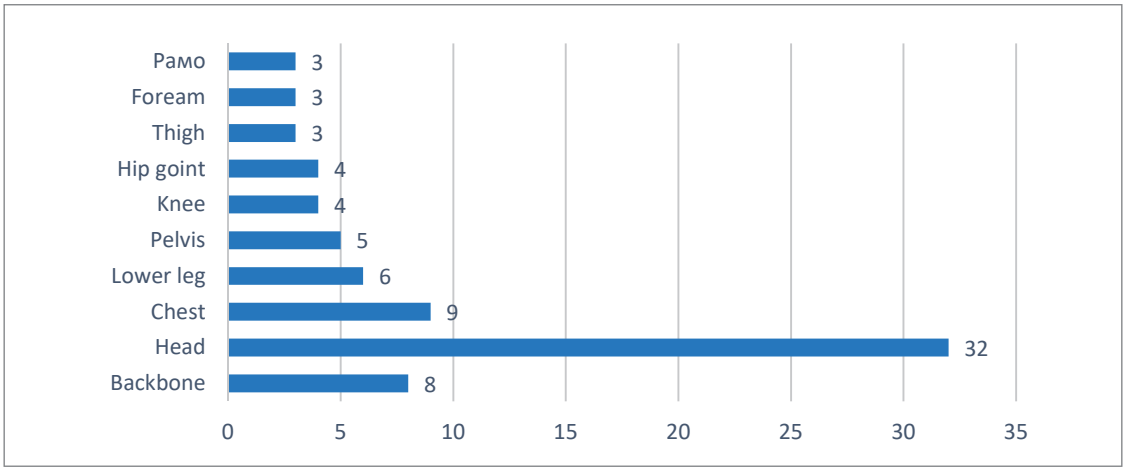


Figure 9. Location of injuries in Borovets that required immediate further help.
Slika 9. Lokacija ozljede u Borovcu that required immediate further help.

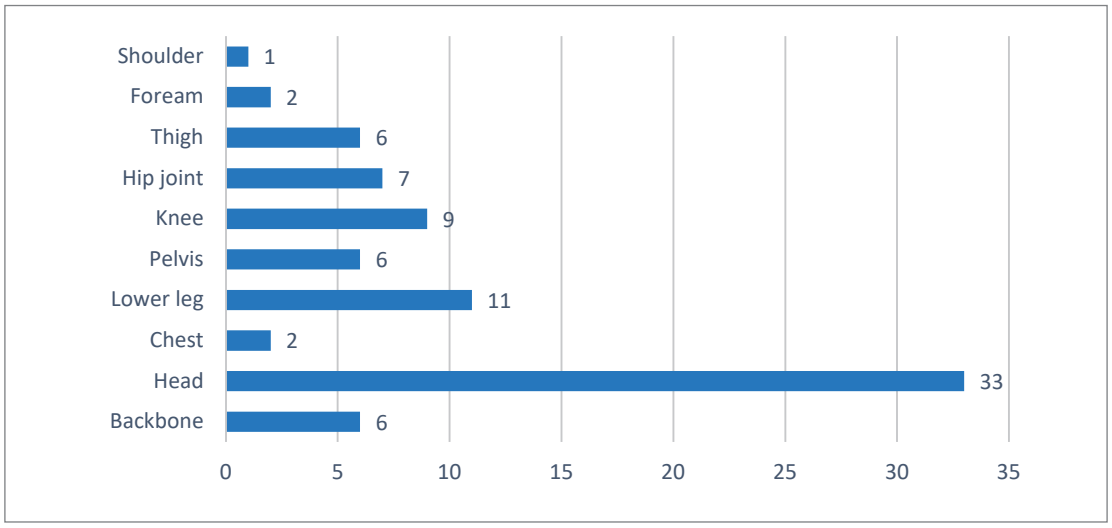


Figure 10. Location of injuries in Pamporovo that required immediate further help.
Slika 10. Lokacija ozljede Pamporovo that required immediate further help.

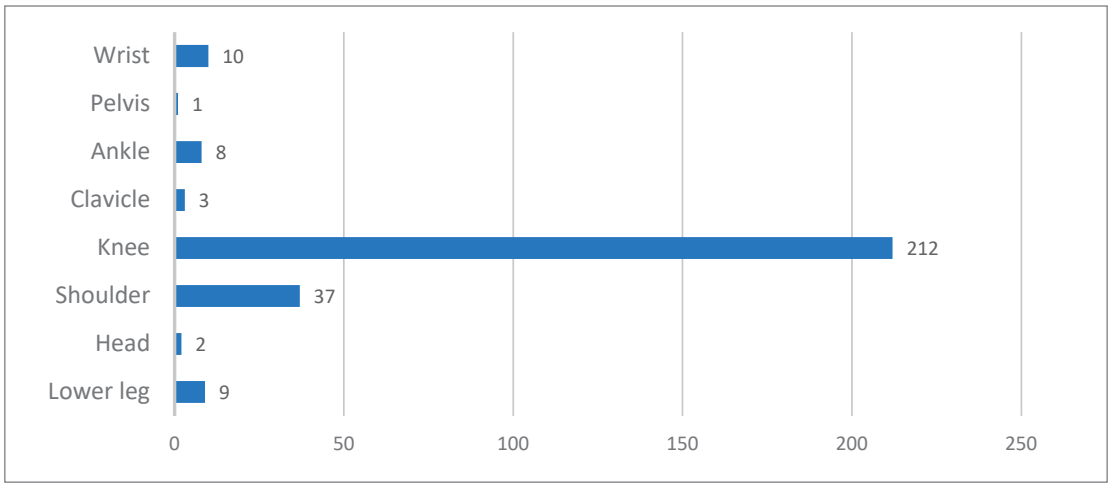


Figure 11. Joint injuries in Borovets (N).
Slika 11. Ozljede zglobova u Borovcu (N).

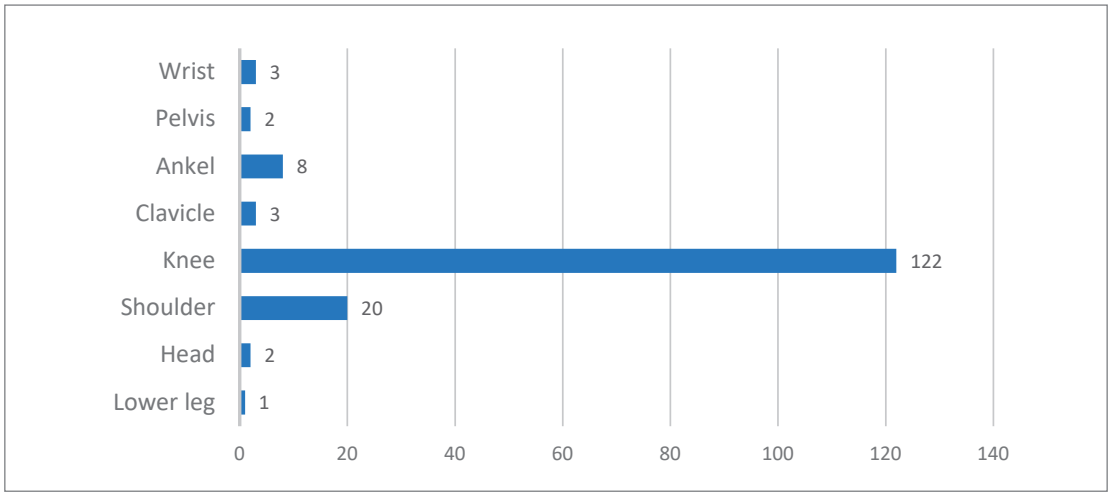


Figure 12. Joint injuries in Pamporovo (N).
Sloka 12. Ozljede zglobova u Pamporovu (N).

experienced by skiers and snowboarders. This is likely due to the nature of these activities, which put a lot of stress on joints, particularly during falls, sudden changes in direction, and impact with obstacles or other skiers. Knowing that on outside leg the forces on anterior cruciate ligament in frontal and sagital plane are extremly high[8] , it is not surprising that the ACL is often torn. ACL In the Borovets ski area, knee injuries stood out as being significantly more common than in the Pamporovo area. This discrepancy can likely be attributed to the differences in slope difficulty between these two regions. Borovets offers more challenging terrain with steeper and longer slopes, which increases the strain on the knees, especially for skiers who might be less experienced or who overexert themselves in these conditions. This higher rate of knee injuries suggests that the terrain complexity plays a crucial role in the type and frequency of joint traumas sustained by skiers.

Another category of severe and often debilitating injuries in snow sports are bone fractures. Fractures can range from minor breaks to complex compound fractures, depending on the nature of the fall or collision. The data collected from both Borovets and Pamporovo ski areas show that lower leg fractures are particularly common. In fact, the number of lower leg fractures was among the highest recorded, with Borovets reporting 30 cases and Pamporovo closely following with 29 cases. This high incidence of lower leg fractures is indicative of the risks associated with skiing and snowboarding, where falls at high speed or sudden impact can cause the lower extremities to bear the brunt of the force. These injuries are often more severe than joint injuries and typically require longer recovery periods, significantly affecting a skier's ability to return to the sport.

It is also noteworthy that Pamporovo ski area registered a considerable number of fractures affecting the upper body. This includes fractures of the arms, shoulders, and clavicle, which suggests that there may be specific environmental or behavioral factors at play in Pamporovo that increase the likelihood of upper body injuries. It is possible that skiers and snowboarders in this area are more prone to falls that result in the upper body taking the impact, or it may reflect different skiing techniques or postures commonly adopted on these slopes. Figures 13 and 14 in the study illustrate these findings and provide a visual representation of the distribution and frequency of fractures across different parts of the body in both ski areas.

The higher number of upper body fractures in Pamporovo compared to Borovets might also be related to variations in slope design, skier behavior, or even the type of snow and weather conditions prevalent in the region. Understanding these differences is essential for ski area managers and health professionals to develop targeted strategies for reducing the risk of such injuries. For example, ski resorts could introduce more extensive safety briefings, increase signage on slopes with a history of high injury rates, or even redesign certain runs to make them safer. Due to the specifics of the equipment and, more precisely, the rugged ski boot, which firmly fixes the ankle, all the tension and effort is shifted to the lower leg and knee resulting in injury.

We attribute the high incidence of injuries on easy slopes primarily to poor skiing culture and inappropriate behavior, such as failing to adhere to FIS rules and engaging in excessive speeding. These factors seem to play a critical role in contributing to accidents that occur even on slopes that are considered less challenging. Furthermore, the unusually high number of injuries to the upper parts of the body—particularly the head and chest—supports the idea that unsafe skiing practices are prevalent in this area, as these types of injuries are less common in other ski regions where safety protocols and skiing culture are more strongly emphasized. This trend indicates that there is a significant issue with skiers not following basic safety rules, such

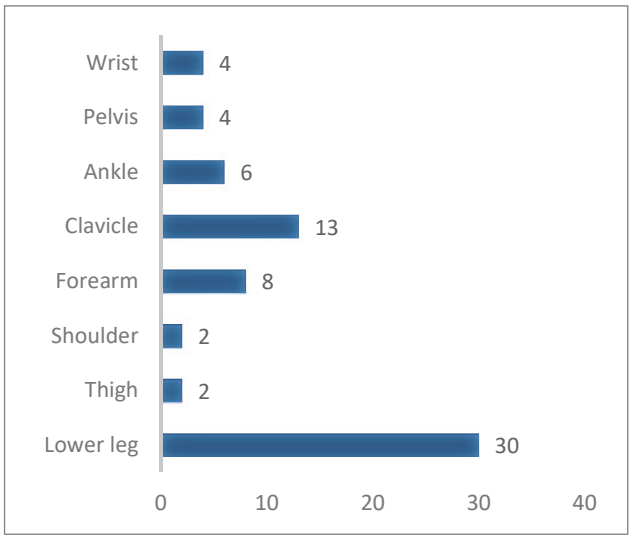


Figure 13. Types of fractures in Borovets.
Slika 13. Vrste prijeloma u Borovets.

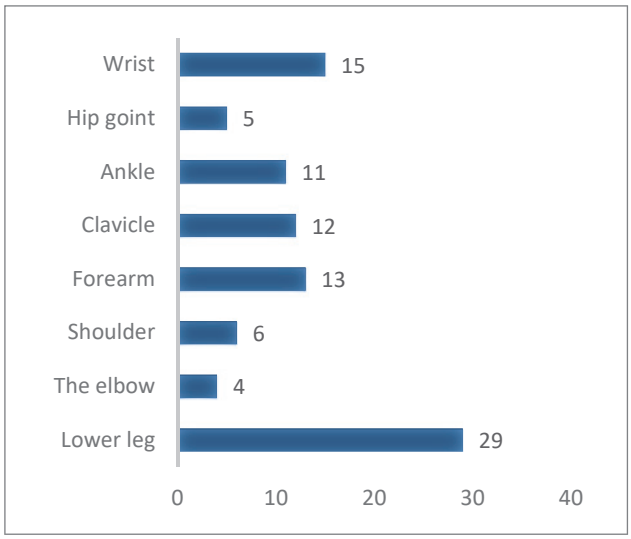


Figure 14. Types of fractures in Pamporovo.
Slika 14 . Vrste prijeloma u Pamporovo.

as wearing helmets, which is reflected in the increased incidence of head injuries.

The high number of head injuries observed in these areas is most likely due to the relatively low rate of helmet usage. While helmet-wearing has become more common worldwide, the lower adoption rate in these regions indicates a need for more robust safety campaigns and stricter enforcement of helmet requirements. Severe injuries such as fractures, which predominantly occur between 12 pm and 4 pm, are also noteworthy. These injuries were mostly reported on blue slopes and were commonly localized in the lower legs, wrists, or clavicle area. The timing of these incidents suggests that fatigue and reduced concentration in the afternoon could be additional contributing factors. This pattern highlights that while these slopes are designed for beginners and intermediate skiers, the risk of injury remains significant due to the combined effects of fatigue, inexperience, and poor adherence to safety rules.

In addition to poor discipline and inadequate safety measures, it is reasonable to assume that these detected injuries represent only one part of the overall problem. The underlying causes of these incidents are likely more complex and multifaceted, involving both behavioral and environmental factors. Experts in snow sports safety in Bulgaria have made several attempts to address these issues. They have suggested that stress factors, which disrupt balance and coordination, may be contributing significantly to the frequency of accidents. In response, Zdravcheva et al.[21] proposed introducing unfamiliar, new, and complex coordination exercises during training sessions. These exercises could mimic real-life loss-of-balance situations that skiers frequently encounter on slopes. By training skiers to handle these scenarios better, it may be possible to improve their overall stability and reduce the likelihood of accidents.

Moreover, it is worth noting that the slopes with the highest number of reported incidents in both regions are those that connect to many other slopes. This observation suggests that the current traffic organization and safety measures are not sufficient and may, in fact, exacerbate the risk of accidents. High-traffic areas where multiple slopes intersect create a chaotic environment, making it difficult for skiers to navigate safely. Therefore, we believe that a more thoughtful ski resort layout, improved signage, and more effective crowd management strategies are necessary to alleviate this problem. Ensuring better traffic flow and reducing congestion at these intersections could play a significant role in decreasing the number of incidents.

Despite the lack of detailed data on the number of visitors, which remains a key limitation of this study, the total number of reported incidents is still significant. This indicates that, even without precise visitor numbers, there is a pressing need for ski resorts to reassess their safety protocols. Lift operators and resort management should prioritize implementing stronger safety measures and enhancing control over skier behavior on the slopes. Better monitoring, more frequent patrols, and stricter enforcement of speed limits could all contribute to creating a safer skiing environment.

In conclusion, while the findings of this study are constrained by limited data, the observed patterns suggest that poor skiing practices, inadequate helmet usage, complex slope layouts, and insufficient traffic management probably play a role in the high incidence of injuries. Addressing these issues requires a multifaceted approach that includes better education on safe skiing behavior, improved infrastructure, and more effective enforcement of existing safety regulations.

Acknowledgments

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References

1. Mountain Rescue Service of the Bulgarian Red Cross. Annual Report- Facts and Figures. Sofia, Bulgaria, 2023.
2. Baschera D, Hasler RM, Taugwalder D, Exadaktylos A, Raabe A. Association between head injury and helmet use in alpine skiers: cohort study from a Swiss level 1 trauma center. J Neurotrauma. 2015;32(8):557-62.
3. Carus L, Castillo I. Managing risk in ski resorts: Environmental factors affecting actual and estimated speed on signposted groomed slopes in a cohort of adult recreational alpine skiers. PLoS One. 2021;16(8):e0256349.
4. Davey A, Endres NK, Johnson RJ, Shealy JE. Alpine Skiing Injuries. Sports Health. 2019;11(1):18-26
5. Dickson TJ, Terwiel FA. Injury trends in alpine skiing and a snowboarding over the decade 2008-09 to 2017-18. J Sci Med Sport. 2021;24(10):1055-1060.
6. Haaland B, Steenstrup SE, Bere T, Bahr R, Nordsletten L. Injury rate and injury patterns in FIS World Cup Alpine skiing (2006-2015): Have the new ski regulations made an impact? Br J Sports Med. 2016;50(1):32-6.
7. Hasler RM, Baschera D, Taugwalder D, Exadaktylos AK, Raabe A. Cohort study on the association between helmet use and traumatic brain injury in snowboarders from a swiss tertiary trauma center. World Neurosurg. 2015;84(3):805-12.
8. Heinrich D, van den Bogert AJ, Mössner M, Nachbauer W. Model-based estimation of muscle and ACL forces during turning maneuvers in alpine skiing. Sci Rep. 2023;13(1):9026.
9. https://www.statista.com/statistics/1179557/injuries-skiers-france (accessed 22.7.2022)
10. https://www.snowtrex.co.uk/magazine/safe-skiing/ski-injuries/ (accessed 22.5.2023
11. https://www.toaeasttn.com/5-top-skiing-injuries-how-to-avoid-them/(accessed 22.7.2022
12. https://www.rosenbauminjuryfirm.com/2023-ski-injury-statistics/(accessed 15.3.2023
13. https://health-infobase.canada.ca/winter-sport-injuries/alpine-skiing.html(accessed 20.6.2023
14. Maxwell N, Redhead L, Verhagen E, Spörri J. Ski racers' understanding of sports-related concussion and its management: are contemporary findings and clinical recommendations reaching the target audience, the racers themselves? Br J Sports Med. 2020;54(17):1017-1018
15. Posch M, Schranz A, Lener M, Burtscher M, Ruedl G. Incidences of Fatalities on Austrian Ski Slopes: A 10-Year Analysis. Int J Environ Res Public Health. 2020;17(8):291
16. Ružić L, Tudor A, Radman I, Kasović M, Cigrovski V. The influence of ski helmets on sound perception and sound localisation on the ski slope. Int J Occup Med Environ Health. 2015;28(2):389-94.
17. Sulheim S, Ekeland A, Holme I, Bahr R. Helmet use and risk of head injuries in alpine skiers and snowboarders: changes after an interval of one decade. Br J Sports Med. 2017;51(1):44-50
18. Tudor A, Ruzic L, Bencic I, Sestan B, Bonifacic M. Ski helmets could attenuate the sounds of danger. Clin J Sport Med. 2010;20(3):173-8
19. Yankov P, Todorov D. Simeonov S. Characteristics or incidents and injuries in ski area Borovets during the 2019/2020 season. International Scientific Congress "Applied Sports Sciences". Proceeding book-Volume 2. Sofia, 2022 .p 122.
20. Weber CD, Horst K, Lefering R, Hofman M, Dienstknecht T, Pape HC; Trauma Register DGU. Major trauma in winter sports: an international trauma database analysis. Eur J Trauma Emerg Surg. 2016;42(6):741-747.
21. Zdravcheva M. Stress factors affecting the learning process of students in the Snow Sports course. Yearbook of the Vasil Levski National Sports Academy. Volume 1. Sofia. 2020 Page 419-27.
22. Zgurovski KR, Yankov P. Alpine ski equipment. Sofia, 2007.