

5<sup>th</sup> Scientific Conference  
**SPE BALKAN SKI**

# THE BOOK OF ABSTRACTS



**SPE BALKAN**  
**SKI**  
Science, Practice & Education

**Rogla, 17-21 March 2024**

Ski Instructors Association of Slovenia (SITAS) &  
Science and Research Centre Koper (ZRS), Slovenia



5<sup>th</sup> Scientific Conference  
**SPE BALKAN SKI**  
Science, Practice & Education  
*(Rogla, 2024)*

# The Book of Abstracts



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**Science, Practice & Education**  
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## **SPE BALKAN SKI Science, Practice & Education**

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Rogla, 2024

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## **PLENARY SPEAKERS**

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**Matej Supej, PhD**

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## **HAMSTRINGS MORPHOLOGY AND FUNCTION IMPORTANCE IN YOUTH AND ELITE SKIERS – A MISSING PIECE OF THE PUZZLE?**

**Martino V. Franchi<sup>1</sup>, Daniel Fitze<sup>2</sup>, Jörg Spörri<sup>2</sup>**

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*Presenting author: Martino Franchi*

The demands of competitive alpine skiing involve a high level of physical fitness to perform specific motor tasks and protect them from the risk of injury associated with the sport. As the knee joint is the most frequently injured body part of competitive alpine skiers at all ages, anterior cruciate ligament (ACL) tears are the most frequently diagnosed. Particularly, jump landings and turning maneuvers are crucial because during such movements muscle forces and neural control can strongly modulate ACL loading and injury: it follows that potential insufficient size, force, or recruitment of the hamstring muscle group may result in inadequate knee stabilization. The present talk will focus on already published and novel results on investigations on hamstring morphology and function in youth and elite athletes. Specifically, the talk will present how, in youth skiers, biological maturation influences maximal hamstring muscle strength production and hamstring architecture and size, as the average anatomical cross-sectional area has been found to be a meaningful proxy measure associated with the occurrence of traumatic lower extremity injuries in this young cohort (Fitze et al. 2022). Furthermore, the talk will present unpublished data on hamstring characteristics of elite alpine skiers, in which the relationship between maximal hamstring force production, muscle stiffness and size will be discussed in relation to injury prevention strategies.

## **CAN OLDER SKIERS IMPROVE THEIR FITNESS AS THEY GO DOWNHILL?**

**John Seifert<sup>1</sup>**

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*Presenting author: John Seifert*

As we age, there is a decrease in muscle mass and function where muscular strength and power decrease, an increase in blood pressure, and an increase in balance-related issues. As the loss of functional capacity occurs, social isolation and decreased feelings of happiness may also be experienced. Numerous published studies have noted that physical activity can slow many of these changes. However, it has been reported that physical activity levels can decrease by upwards of 70% in the elderly during the winter months. Alpine skiing could be a viable option to improve activity levels during the winter. Current physical activity guidelines to gain healthful benefits include aerobic-based activities of at least 150 minutes/week of moderate-intensity or 75 minutes/week of vigorous activity with an exercise intensity range of 50-80% maximal heart rate. Seifert et al. (2016) reported that heart rate during skiing met the recommended guidelines during a single run while Stöggel et al. (2016) noted that energy expenditure during 2.5 hours of alpine skiing is comparable to an hour of Nordic skiing. In a group of articles published by the Salzburg Skiing for the Elderly Study, indicators of functional capacity and muscle quality increased significantly in skiers when they skied for 28 days over a 12-week period. Additionally, in an unpublished study, Seifert found that balance, blood pressure, and happiness significantly improved in elderly skiers over a full ski season. In conclusion, while skiing cannot stop the aging process, there are both short- and long-term health benefits to skiing. It appears that skiing a minimum of twice/week throughout the ski season results in positive physical and mental adaptations.

**KEYWORDS:** aging, muscle function, long-term skiing.

**References:**

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## SKIS AS A POTENTIAL RISK FACTOR IN ALPINE SKIING

Matej Supej<sup>1</sup>

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*Presenting author: Matej Supej*

The recreational activity of alpine skiing has a higher incidence of injuries compared to other sports, with between 2.4 and 7.0 injuries per 1,000 activity days. Competitive skiing further increases the risk of injury, with one-third of World Cup athletes experiencing injuries per season. Interestingly, 71% of these injuries occur during competitions, despite presumed greater safety measures being taken during events. In the current season, there is a noticeable number of injured top skiers in the World Cup, including Schwartz, Kilde, Shiffrin, and Vlhova. The purpose of this presentation is to explore the potential role of skis in competitive alpine skiing injuries.

The ski plate-binding-boot system has been identified as the primary key risk factor in World Cup alpine ski racing, while individual components within this system were rated relatively low on the perceived risk scale. In the presentation, the components of the ski will be analyzed in a structured manner and their significance in relation to the risk of injuries will be evaluated based on available literature. Additionally, relevant factors such as snow conditions and the effectiveness of protective nets in preventing accidents will be addressed, as injuries often occur when a skier collides with a protective net while skiing at high speeds with fastened skis.

**KEYWORDS:** competitive skiing, injury risk, skiing safety, skis' properties, ski bindings, ski plates.

**References:**

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## ALIGNING ASSESSMENTS WITH JOBS: WORKFORCE DEVELOPMENT

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*Presenting author: Pete Allison*

**INTRODUCTION:** Teaching snowsports as a career is accepted and recognized to varying extents around the world. In the USA the workforce of snowsports educators involves a relatively small number of full-time staff and a large number of part time staff primarily working over weekends and holiday (vacation) periods. Recognition of the skills of snowsports educators is desirable as a means of providing recognition of the skills and their transferable value both within snowsports careers and beyond.

**METHODS:** This presentation will present the process and findings of 7 years of curriculum development and implementation across the USA.

**RESULTS:** Progress towards greater alignment and consistency of assessment processes across the USA and development of instructor skills to enhance the quality of teaching and learning will be presented.

**DISCUSSION:** Challenges, opportunities, and next steps will be presented for discussion and debate.

**KEYWORDS:** Quality, workforce development, transferable skills, standards.

**References:**

*Pighetti, J., Mateer, T. J., & Allison, P. (2022). Dimensions of snowsports education: A review of literature. Journal of Outdoor Recreation, Education, and Leadership, 14(3), 93-106.*

## ANALYZING MOVEMENT ANALYSIS

**Ronald Kipp<sup>1</sup>**

*<sup>1</sup>Team Palisades Tahoe, USA*

*Presenting author: Ronald Kipp*

**INTRODUCTION:** Movement analysis (MA) is a term used in snowsport instruction and coaching. Despite its rather definitive moniker, it has evolved into a catch-all phrase for everything descriptive and prescriptive in teaching and coaching. Snowsport instructors learn MA strategies such as “start at the skis and work up”, or the “wheel” approach which starts at the core and works out among others approaches. High-tech MA includes kinematics, kinetics, and muscle activation. While objective data is interesting and useful, it is obviously too slow and cludgy for coaching applications. The hypothesis of this paper is to lay out the neurologic stages. Beginning with a motor movement and utilizing inductive logical reasoning to arrive at a more accurate assessment of the subject’s performance. When this is achieved, feedback and advice are tempered and there is a greater probability of subject improvement.

Stages of Movement Analysis:

Perception. This involves all human senses but is traditionally limited to sight. When light enters the eye and hits the retina, photoreceptors turn light into electrical signals. These signals travel via the optic nerve to the brain where, if conditioned sufficiently, is identified as an image.

Understanding. To make the image identifiable it must be connected to a concept. Without this link, the image has no meaning or value. This is where vocabulary and the associated understanding are essential. As comprehension is increased the utility of the concept is enhanced. For example, if “angulation” is noticed in the skier, one instructor might just categorize it as a sideward bend in the body. Another instructor will see the “angulation” as an articulation between the femur and pelvis. A third instructor will fill in more information and notice it is allowing for a more countered body position while edging the ski. Each case is correct. As more information is garnered and classified, understanding is enhanced, and the upcoming prediction will increase in effectiveness.

Prediction. Using words like angulation or edging to distinguish concepts, allows the instructor or coach to make predictions. Increasing the

validity of a prediction is dependent on the depth and breadth of understanding. Imagine a skier is leaning and rotating at the end of their turn. If the instructor only had a concept for learning, they would see only an edging problem and suggest some edging drills. If this instructor had a concept of rotation, then they would weigh out the differences between edging and rotatory drills, enhancing the learning experience for the student.

To summarize, the snowsport practitioner needs more than a recipe for optimal MA. Recognizing what they see and being able to understand the concept behind the movement(s) is essential. Only then can they accurately categorize the action(s). Then like filling in the blanks of a jigsaw puzzle, the more pieces of the puzzle that are identified and placed in the puzzle picture the greater the likelihood they will be correct in detecting the picture.

**KEYWORDS:** Movement analysis, pedagogy, prediction, decision making.

**References:**

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## OCCURRENCE AND TRENDS OF ACCUMULATED AND ACUTE INJURIES OR PAINFUL SENSATIONS AMONG SKI INSTRUCTORS

Siniša Kovač<sup>1,2</sup>, Denis Čaušević<sup>2</sup>, Erol  
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<sup>2</sup> Faculty of Sport and Physical Education, University of Sarajevo, BIH

Presenting author: Siniša Kovač

**INTRODUCTION:** Musculoskeletal disorders (MSD) are incredibly common and are often related to workload. Occupational health and injury prevention research has the potential to help mitigate MSD in the workplace. This study aimed to determine how the work demands of ski instructors may affect the health of their musculoskeletal system. The second aim is to describe the occurrence of accumulated and acute injuries or subjective painful sensations among ski instructors.

**METHODS:** A cross-sectional study involved the participation of 109 ski instructors. Observed variables were the prevalence of MSD measured using a modified Nordic questionnaire about injuries during the previous ski season (neck, shoulders, elbows, wrist, upper back, lower back, one or both hips, one or both knees and ankle) as well as subjective painful sensation occurrence during and after ski season. Means and standard deviations for each of the variables were calculated, and differences between genders were examined using an independent sample t-test.

**RESULTS:** Prevalence of MSDs in ski instructors was most common in the neck (13.8%), shoulders (12.6%), elbows (4.6%), wrist (9.2%), upper back (10.3%), lower back (46.0%), one or both hips (9.2%), one or both knees (29.9%), and ankle (9.2%). The results showed statistically significant differences in MSD between genders in the neck ( $p=.034$ ); shoulders ( $p=.017$ ); upper back ( $p=.027$ ); one or both knees ( $p=.003$ ) and in the ankle joint ( $p=.011$ ).

**DISCUSSION:** MSDs are common in ski instructors, especially in the lower back and knees of female employees. Future research or injury prevention programs would benefit these populations. The results showed that in the past ski season, the incidence of musculoskeletal disorders for certain body segments among ski instructors in Bosnia and Herzegovina was between 9.2% and 46%. The problem of "back pain"

most often occurs in the most productive period of a person's life, between thirty and fifty years of age, equally often in people of both sexes. As expected, the largest number of respondents of both sexes stated that they had problems with lower back pain and knees, during the past ski season. Lumbar pain syndrome is one of the most common health problems today and the most common cause of absenteeism from work.

**KEYWORDS:** skiing, injuries, health issues, MSD, occupation, kinesiology

**References:**

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*Patrick E, Cooper JG, Daniels J.(2015): Changes in skiing and snowboarding injury epidemiology and attitudes to safety in Big Sky, Montana, USA: a comparison of 2 cross-sectional studies in 1996 and 2013. Orthopedic journal of sports medicine. 24;3(6):2325967115588280. doi: <https://doi.org/10.1177/2325967115588280>*



## TRACKS IN THE SNOW: EXPLORING THE SOCIALIZATION OF ALPINE SKIING

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*Presenting author: Saša Pišot*

**INTRODUCTION:** Why do we like to ski and enjoy making turns? Skiing is not only a physical activity, but also a social and cultural experience that encompasses various aspects beyond the technical skills of skiing itself. But why in general do people play sport? What happens to them when they play sports? How does sport influence ideas and beliefs? To answer these questions, the sociology of sport focuses on a process of social learning and development – the socialization. Nowadays discussion of socialization through sport refers to the process of becoming involved in sports, the process of transitioning out of active sports participation, the consequences of being involved in sports and socialization as a community and cultural process.

**METHODS:** Using some theoretical frameworks (cultural studies, interactionist and structural theories) and autoethnography (author's self-story or personal narrative) as a qualitative research method to gain insights into broader cultural or social phenomena, participation in alpine ski racing in the 1980s is presented through the main notable factors of socialization.

**RESULTS:** The auto-ethnographic story provides answers to the questions posed above and reflects the main components of her personal experience when she started training alpine skiing at the age of seven, under the influence of significant others (a family friend) and family support together with the opportunities (access to ski slopes) and the supportive cultural context (social collectivism in the former Yugoslavia, Slovenia's identity as a skiing nation, "ski pool" funding system). She built a successful sporting identity as a member of the national youth team, but her sporting activity was ended by an injury at the age of 17. An insight into the period of transition from the role of an injured athlete to taking on new roles as a student, ski instructor, mother and researcher suggests a story with more positive than negative experiences of sport participation.

**DISCUSSION:** Although many similar stories are dominated by positive experiences, it is important to be aware that sports experiences are

diverse and not unique. Apart from the fact that the meanings given to sport experiences vary from person to person and that people change during their participation in sport, also relationships and context matter. For this reason, most sport sociologists today view sport as a site for socialization experiences rather than as a cause of particular socialization outcomes. This distinction recognizes that it is possible to have powerful and memorable experiences in sport. However, the impact of these experiences depends on the relationships through which they are given meaning, as well as the social and cultural factors that influence how these meanings are integrated into people's lives.

**KEYWORDS:** sport participation, socialization, experiences, alpine skiing.

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# SCIENTIFIC ABSTRACTS

## RECOVERY METHODS AND PRE-HAB EXERCISES IN REDUCING THE INCIDENCE OF INJURIES IN ALPINE SKIERS

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**INTRODUCTION:** There are a number of common risk factors in alpine skiing that can lead to athlete injuries, ranging from a continual repetition of an action, using a poor technique, level of fitness and body composition, correct warm up, cool down and mostly using recovery as part of the training.

**Purpose:** We conducted a systematic review study trying to analyze the injury incidence in skiers, location, severity, type, cause and the use of recovery and prevention methods in their daily training.

**METHODS:** We searched PubMed, Web of Science for studies on the role of recovery, and prevention in injury incidence of skiers.

**RESULTS:** Ski puts tremendous strain on the knees, ankles, and hips, but also on the hamstrings, groins, abdomen and quads. The lower extremity is most frequently injured, and contusions are the most common type of injuries.

**CONCLUSIONS:** Skiing requires total body fitness: strength, power, core, proprioception, flexibility, cardiovascular fitness, but also proper and adequate recovery methods, appropriate nutrition, hydration, sleep, good warm up & cool down and using specific pre-hab exercise in order to minimize the incidence of injuries. Bad recovery and lack of prevention exercises cannot support good training and may lead to injuries.

**KEYWORDS:** alpine skiing, fitness, recovery injuries.

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## DENIAL OF PAIN AND SPORTS INJURIES

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**INTRODUCTION:** In the biomedical framework, sports injuries are usually understood as physiological events, and the study of their causes is based on the characteristic boundaries of the human body as a physiological entity. This often neglects the multifaceted influences that shape the understanding of injuries. However, it is crucial to recognize that the human experience transcends mere physiological dimensions, and the interpretation of an individual's injury occurs within a broader cultural and social context. This also applies to the domain of pain associated with sports injuries. The case study of elite Slovenian cross-country athlete Petra Majdič illustrates how pain is culturally constructed and remains intertwined with the concept of meritocracy in the context of elite sport. The study illustrates the complex interplay between physiological processes, cultural factors, and socio-structural dynamics, which together shape the comprehensive understanding of sports injuries and the perception of pain.

**METHODS:** In this study, a systematic literature review was chosen as the method that formed the theoretical basis, for the review of articles sourced from newspapers and magazines.

**RESULTS:** Sports injuries as a necessary price for success. Denying or overcoming pain is portrayed as a symbol of courage, excellence, and unwavering dedication. The literature underscores this pervasive notion that athletes, who suffer an injury, are not only expected to persist in their performance but are also praised for doing so, fostering a narrative that downplays the emotional and physical toll of such injuries. This ingrained and normalized view suggests that the ability to overlook or overcome pain serves as a mechanism for athletes to ascend the sporting hierarchy and increase their standing. This belief, referred to as the "meritocratization of pain," holds that athletes willingly endure adversity, including severe injury, as an indispensable element for success in their careers. Refusing to admit pain is seen as a sign of courage and a symbolic representation of excellence and unwavering commitment. In the Slovenian sports context, Petra Majdič's

performance at the 2010 Winter Olympics in Vancouver is a vivid example of the meritocratization of pain.

**DISCUSSION:** Sports injuries and the pain associated with them should be examined in the institutional context in which athletes operate. The headlines in articles about Petra Majdič's performance at the Vancouver Olympics are characterized by a clear glorification of injuries and pain. Examples such as "Petra with heroic performance to 'diamond' bronze!" and "Heroine Majdič has four broken ribs" emphasize the heroic nature of her performance without adequately addressing the severity of the injury or its consequences. This raises important questions about possible complications or lasting consequences during the performance that could affect Petra's health and quality of life after her sporting career. The absence of such considerations in the discourse surrounding the athlete's performance highlights the need for a more comprehensive evaluation of the institutionalized framework surrounding sports injuries and their representation.

**KEYWORDS:** Sports injuries, Meritocratic pain, denial of pain, Petra Majdič.

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## CHARACTERISTICS OF INCIDENTS AND INJURIES IN PAMPOROVO SKI AREA AND BOROVETS SKI AREA FOR SEASON 2019-2020

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**INTRODUCTION:** Although in Bulgaria there is a sub-law from the law of tourism, regulating the security and safety of the users of the ski slopes in Bulgaria, not enough attention is paid from the point of view of reasons for the accidents, feedback and prevention of injuries in the snow sports. The aim is to research the type of accidents and traumas in ski-zone Borovetz and ski-zone Pamporovo for 2019/ 2020 year on various indications – hour of occurrence of the trauma, slope complexity, type of the trauma, type of the ski or snowboard equipment. The tasks reviewed, determine the type of trauma with skiing and snowboarding.

**METHODS:** frequency analysis, analysis of documents, comparative analysis.

**RESULTS:** We distributed the traumas into four sub-groups: head, body, legs and arms. It appeared, that the biggest number of traumas are the ones of the legs, followed by those of the arms. In the slope accident, the most common trauma is on the knee joints, followed by shoulder and lower leg injuries. From those traumas, we reviewed the most severe traumas – the fractures. The most registered fractures are the ones of the lower leg and the collarbones. After 12:00 is the peak of severe injuries in both ski areas. This is somewhat understandable from the fact that after 12:00 the slopes are no longer in good condition due to the weather conditions (sun, wind, positive temperatures) and also from the use of the slopes by other snow sports tourists.

**DISCUSSION AND CONCLUSION:** Borovets is the second most accident-prone resort in Bulgaria and Pamporovo is the third for the period. The largest percentage of injuries are those of the lower limbs, registered in alpine skiing in both ski areas. Incidents in the ski area Borovets occur mainly on the "blue slopes" and in Pamporovo on the "green slopes". We recommend the concessionaires of the ski areas in Bulgaria to turn to experts in the field of snow sports for the prevention and reduction of accidents on the slopes. For more accurate and good statistics, we



recommend the Mountain Rescue Service to revise the protocol to be filled in case of an accident - to note whether the injured are organized with a group or individual practitioners and whether the practitioners are skiing or snowboarding. It is missing whether the injured are wearing protective equipment (helmet).

**KEYWORDS:** prevention, reduction, traumas, security.

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## SHAPING THE FUTURE OF SNOW SPORTS: A COMPREHENSIVE REVIEW OF SUSTAINABILITY IN SNOW SPORTS

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**INTRODUCTION:** In the face of evolving challenges, our review reimagines the future of snow sports, emphasizing the pivotal role played by trends and the responsive measures taken within the snow sports community. We delve into the perceptions, strategies, and initiatives shaping the outlook of this dynamic industry.

**METHODS:** To garner insights into the trajectory of snow sports sustainability, we conducted a comprehensive survey. The survey, focusing on environmental impact and financial accessibility, invited participants to share their subjective opinions, perspectives on ongoing trends, and ideas for meaningful action.

**RESULTS:** Participants, drawn from the snow sports community, provided invaluable perspectives on key factors influencing sustainability. The survey unveiled a growing concern regarding the impact of diminishing snow availability, intensifying the urgency for eco-friendly practices and sustainable snowmaking technologies. Financial barriers emerged as a substantial hurdle, with participants expressing apprehension about the increasing cost of skiing, underscoring the need for inclusive pricing models. Moreover, respondents highlighted the changing landscape of snow sports enthusiasts, emphasizing the importance of adapting to varying functional capacities. The survey shed light on the disruptive influence of emerging technologies, revealing the sector's need to embrace innovation to remain competitive.

**DISCUSSION:** Our findings underscore the critical need for a holistic approach to sustain and enhance the future of snow sports. Addressing environmental concerns requires concerted efforts toward sustainable practices, such as eco-friendly slope management and responsible snowmaking. Tackling financial barriers necessitates collaborative strategies, and exploring innovative pricing models to ensure broader accessibility. Adapting to the evolving demographic landscape demands

inclusive measures that cater to individuals with diverse functional capacities, ensuring the continued engagement of a broad audience. Embracing technological advancements becomes imperative, not as a threat, but as an opportunity to augment traditional snow sports experiences and attract a new generation of enthusiasts.

**KEYWORDS:** Snow sports, sustainability, environmental conservation

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## ALPINE SKIING INJURIES AND RECOMMENDATIONS FOR THEIR PREVENTION IN PRIMARY AND SECONDARY SCHOOL PROGRAMS

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**INTRODUCTION:** In Slovenia, winter sports represent national consciousness and tradition. Namely, Alpine skiing is one of the most widespread snow sports. In order to preserve this tradition and inspire the next generation of children and youths, winter sports are part of the educational process in primary and secondary schools. For primary school children, participation in sports days is compulsory, where children are encouraged to take part in a wide range of winter sports activities. It is recommended that winter sports should be included in primary schools every year at least once a year. In addition to sledging, snow games and ice skating, skiing is most often offered. Primary schools also organize five-day-long winter outdoor schools, usually in 6th Grade, for which students sign up voluntarily. Usually, students learn how to ski as a beginner or build on their advanced skiing skills in winter nature schools. In the lower secondary school, there are two sports days per year in the first three years and one in the last year. Three additional sports days per year can also be offered as part of compulsory electives, which are chosen by the students themselves. Of course, on all sports days and nature schools, the safety of students should be the number one priority. Since we believe that most injuries can be prevented by a systematic, gradual and appropriate methodology, we have analyzed the available sources on youth surfing injuries in the first part of the paper. The second part is the following, where we have made recommendations for their prevention.

**METHODS:** We searched the PubMed database using the keywords "injuries, skiing, youth". Therefore, only studies with these strings are used in this paper.

**RESULTS:** Research has shown that most skiers suffered head injuries, followed by shoulder injuries and lower limb injuries, especially the knees. The most common mechanisms of injury are falls and collisions with objects on/near the ski slope. The most common type of injury is fractures. Surprisingly, skiers wearing helmets were more likely to be injured than those not wearing helmets, as they are more courageous and take more risks when wearing protective equipment.

**DISCUSSION AND CONCLUSIONS:** Recommendations to prevent injuries in young skiers should include a strict working methodology that is gradual and systematic. Depending on their level of knowledge, we need to choose the right terrain and familiarize them with the rules of the ski slope. It is important to realize that most injuries are to the lower limbs, especially the knee (left), as well as to the head and shoulders. For this reason, we need to physically prepare children and young skiers for such activity. Of course, mental preparation is also necessary. We need to give children and young skiers knowledge about the use of ski equipment, such as the length of skis and how to adjust the bindings on them, the size and fit of helmets and the use of pads.

**KEYWORDS:** injuries, alpine skiing, school programs, youth, recommendations, prevention.

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## INVESTIGATING NEUROMUSCULAR ACTIVITY IN ALPINE SKIING: THE TRANSITION FROM BIPOLAR TO HIGH-DENSITY ELECTROMYOGRAPHY

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**INTRODUCTION:** Surface electromyography (sEMG) is a non-invasive method for measuring muscle activity. In a bipolar setting (BI-sEMG), this technique involves placing two electrodes over a muscle to detect the difference in voltage between these points, reflecting muscle activity. In the context of alpine skiing, BI-sEMG has provided valuable insights. It has been used to study various skiing techniques, the impact of different equipment on muscle activation, and to understand the neurophysiological effects in skiers of diverse expertise, including parathletes and the elderly. BI-sEMG has facilitated the examination of fatigue effects, spinal excitability, and the impact of various training modalities on muscle activity in skiing. However, its limitations are evident in the complex, dynamic environment of skiing. The restricted spatial resolution and sensitivity to changes in muscle geometry during movement can lead to potential misinterpretations, especially in intricate muscular activities like skiing.

**ADVANCEMENTS OF HD-sEMG:** The emergence of high-density surface electromyography (HD-sEMG), particularly the computer algorithms enabling its decomposition into single motor units (MUs) contributions, is revolutionizing muscle activation analysis and opens new possibilities for studying voluntary movement control by the central nervous system. It allows for examining MU firing frequency patterns, MU firing thresholds, and the contributions of the neuromodulatory system to muscle activation. These aspects, unattainable with BI-sEMG, are crucial for understanding neural control in various athletic disciplines and pathologies.

**POTENTIAL USE OF HD-sEMG IN SKIING RESEARCH:** To date, this technology has not yet been implemented in alpine skiing-related research. HD-sEMG could be exceptionally valuable in analyzing both acute and chronic effects of skiing, such as fatigue and training adaptations. For instance, in elderly skiers, HD-sEMG could unveil the

neural mechanisms behind fitness improvements from recreational skiing, significantly contributing to geriatric sports science.

Furthermore, the advent of wearable HD-sEMG technology extends its application to dynamic conditions. While challenges in interpreting BI or HD-sEMG signals in dynamic conditions persist, HD-sEMG offers superior spatial resolution and broader muscle area coverage. This leads to a more detailed and accurate understanding of muscle activation. HD-sEMG could provide novel insights into neurophysiological markers previously unachievable with BI-sEMG. For example, activity maps generated by HD-sEMG can identify innervation zones and different muscle compartments. In contrast, its ability to assess muscle fiber conduction velocity offers fresh perspectives on muscle function and fatigue analysis in skiing.

**CONCLUSIONS:** In conclusion, integrating HD-sEMG into alpine skiing research marks a significant advancement in understanding the neuromuscular demands of the sport. It enhances performance and training methodologies and plays a crucial role in injury prevention and rehabilitation, particularly for special populations.

**KEYWORDS:** muscle activation, neuromuscular control, EMG.

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## **STRUCTURING OF THE MOTOR LEARNING FEAR ASSESSMENT QUESTIONNAIRE IN ALPINE SKIING**

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**INTRODUCTION:** The methodology of the Slovenian Alpine Skiing School is defined by five levels of skiing knowledge. The first level of knowledge requires knowledge of safe handling and behavior on the ski slopes, knowledge of how to use the equipment; and basic skiing (positions on the skis in place and during gliding; simple changes of the skiing direction with wedge turns) on a flat or laid terrain. The second level of knowledge represents beginner skiing (ski curves with wedge turns, turns with wedge push-off) on laid to less steep terrain. The third level of knowledge represents advanced cross-terrain skiing (basic swinging, swinging in a wide corridor with a curving technique) on less steep terrain. Skiing knowledge at the fourth level includes superior cross-terrain skiing on terrains of all inclinations (combined skiing in corridors of different widths; with an emphasis on dynamic skiing in a narrower corridor). The fifth level of knowledge requires the mastery of competitive turns on the ski track between the gates. In practice, we notice that the effectiveness of learning alpine skiing mostly depends on the physical abilities and movement efficiency of the student, but also from his fear of learning new/unknown/specific skiing movements. The student's physical condition is defined by the level of his physical fitness. Movement efficiency with the acquired level of movement skills of sports that are similar to movement in alpine skiing (e.g. roller-skating, ice-skating); and the level of motor skills acquired (strength, balance, coordination, etc.). From the point of view of movement skills, we know from practice that a student at the first two levels of skiing knowledge must be able to balance his body when making ski turns at a lower skiing speed. At the third level, in addition to good body balance when sliding on skis, coherent, rhythmic and coordinated movement of the body with the planting of the ski poles at a medium skiing speed is also important. Forms of skiing at the fourth and fifth level of knowledge, however, require fast and precise body movements with emphasized power and explosiveness at high and very high skiing speeds. In practice, when



learning to ski, we notice that many students experience fear. This most often affects the efficiency and economy of transition to a higher level of skiing knowledge. For some, the fear (at a certain level) is so big that the individual is unable to advance to a higher level of knowledge. We found that research work in the field of fear assessment in the process of learning alpine skiing and physical movement has not been done yet. We also did not find (from the available sources) any diagnostic tool (e.g. a questionnaire) for assessing fear in the process of learning alpine skiing. Therefore, the main objective of this paper was to describe the structuring of a Motor Learning Fear Assessment Questionnaire (MLFAQ) and applying it to the alpine skiing learning process.

**METHODS:** For questionnaire development, a total of 5 experts in the fields of sports science, kinesiology, skiing, sport psychology, and fear avoidance were called upon to generate and rate items for the MLFAQ. For determining concurrent validity, 120 alpine skiing beginners (students aged 16-25 years) participated. We used factor analysis and reliability analysis to establish the final version of the questionnaire and establish reliability.

**RESULTS:** Reasonably satisfactory reliability was found for the questionnaire, therefore the final version of the questionnaire includes four factors.

**DISCUSSION AND CONCLUSIONS:** We developed a questionnaire, which can be used to measure fear while learning new motor skills. With this research, we structured a practically useful tool for alpine skiing instructors, which enables student-centred learning. At the same time, it can also be used to identify the main limiting factors that prevent the student from progressing to higher levels of skiing knowledge. In this way, according to the Slovenian methodology of alpine skiing, it will be possible to provide the student with even more optimal individualized learning – from beginner to advanced and possibly even to a top-level skier.

**KEYWORDS:** Alpine Skiing, Questionnaire, Fear, Learning, Tool.

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## YEAR-ROUND INTERGENERATIONAL SKI PREPARATION: TRAINING ADVENTURES FOR CHILDREN AND OLDER PEOPLE

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**INTRODUCTION:** Skiing is a physically demanding sport that requires a combination of strength, endurance, balance and technique. While ski training programs are often developed for specific age groups, the concept of intergenerational ski preparation has gained attention as a new approach to improving the overall skiing experience. This paper presents a year-round training program tailored for both children and the elderly that aims to foster a unique intergenerational connection while optimizing the physical and mental fitness required for skiing.

**METHODS:** In this study, a systematic literature review is conducted to identify and summarize research findings that clarify the relationship between physical activity and cognitive engagement in an intergenerational context.

**RESULTS:** Despite the recognized benefits of intergenerational initiatives, few studies have looked at their impact on cognitive health, with initial evidence of positive perceptions, reduction of age-related stereotypes and knowledge sharing between younger and older people. This highlights the need to expand research in this area to shed light on the cognitive benefits that arise from intergenerational interaction in shared physical activities.

**DISCUSSION:** The approach presented in this article, known as NeuroPlay, seeks to address current research gaps by developing and evaluating intergenerational programs that combine physical activity with cognitive challenges. These programs are tailored to non-cohabiting grandchildren and grandparents and have a dual focus: improving motor-cognitive function and well-being and promoting stronger family bonds.

**KEYWORDS:** intergenerational play, elderly, neuroplasticity.

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## **TRANSFER OF KNOWLEDGE TO SOLVE INJURY PROBLEM: FROM TEAM TO SNOW SPORTS**

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Injuries are one of the biggest problems in the modern sports industry, significantly impacting the economy, health, and social status. Despite considerable investments in prevention and specific action taken by numerous associations and organizations to prevent and reduce the incidence of injury, the prevalence of injuries increases year by year. Moreover, the prevalence of injuries increases simultaneously in almost all sports disciplines. For instance, the prevalence of injury in snow sports is 3.49 injuries per 1000 athlete-days. Similarly, the injury incidence in football is estimated at 10-35 per 1000 match hours while other female field-based team sports have injury incidence from 1.2 to 132.7 and 1.2 to 42.1 during a match and training, respectively.

The major limitation of the existing approach to the prevention and prediction of sports injuries is the mono-dimensional approach (i.e., using only one variable at a time to estimate injury risk), based on screening tests to address a complex problem such as injury. Consequently, mono-dimensional approaches are not effective in practice due to low precision (<5%), and screening tests for injury prediction and prevention do not work and probably never will. One of the key issues that can lead to an athlete's injury is a large number of fitness and performance input variables. However, current approaches to injury prevention and prediction only observe and analyze a few variables to estimate injury risk without fully exploiting the complex patterns underlying the available data. Such a mono-dimensional approach cannot solve the complex injury problem due to an inadequate statistical analysis approach unable to combine, evaluate and filter several risk factors to obtain a specific answer for athletes' injury prevention or prediction. In addition, the approach cannot answer the question of who is at risk or which risk factor(s) should be addressed to

mitigate the risk of injury. Fortunately, Machine Learning (ML) is a powerful method of data analysis that is successfully used in medicine to solve similar problems, i.e. automatically diagnosing diseases like lung cancer or strokes based on CT scans, assessing the risk of sudden cardiac death or other heart diseases based on electrocardiograms and cardiac MRI images etc.

In our ongoing project, we hypothesized, that ML methods could be used to detect potential risk factors for injury by combining a large number of fitness, neuromuscular and stress parameters and creating an algorithm/model that will accurately and automatically identify risk factors. In this context, we also considering knowledge transfer between sports disciplines to create a big dataset, improve the ML model, and as such can serve as the tool to tackle the problem of injuries in alpine ski racing, which has become a major issue this year.

**KEYWORDS:** sports injuries, Machine Learning, transfer of knowledge, team sports, snow sports.

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*doi:10.1371/journal.pone.0201264*

## **DECODING MOTOR CONTROL AND LEARNING: BRIDGING THE GAP BETWEEN SCIENCE AND PRACTICE WITH INNOVATIVE TECHNOLOGY**

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**INTRODUCTION:** The new reality in Snowsports requires adjustments to the concept and approach. While keeping the basics, new teaching tools are needed that can be used internationally and are appealing to instructors and kids.

**METHODS:** The international project Erasmus + Sport: SKIEASY (Educational, Accessible, Simple, Youthful) approach to ski skills acquisition in the learning process – led to the development of the unified teaching model - UTM SKIEASY, pocket manuals and an innovative app - SKIEASY MOB APP to support ski instructors and students for a friendly, safe, and effective alpine ski teaching process. The focus of the app is on a simple and friendly teaching method with the integration of modern didactic tools as well as facilitating communication and the exchange of experiences between ski instructors from all over the world in a globalized world. The app provides important information and terminology in different world languages.

**RESULTS:** The SKIEASY MOB APP is compatible with phones, laptops, and tablets. It contains a dictionary for ski equipment, body parts, ski environment, ski technique, didactic tools, and useful phrases. In addition, the standardized SKIEASY teaching model is presented attractively in five steps using avatar videos. Is based on five stages, which have been studied on the basis of theoretical principles and kinematic analyses in order to promote the acquisition of motor/skiing skills triggers and not just the repetition of ski elements/ski types. The ski instructor or app user can choose between 15 languages.

**DISCUSSION:** When the SKI EASY project reached its successful conclusion, it contributed to the satisfaction of over 150 children who experienced their first snow adventures during four SKIEASY snow days. In addition, more than 110 ski instructors have been awarded SKIEASY



training certificates. The impact of the project on the educational landscape of skiing has proven to be far-reaching and significant. Beyond the creation of valuable teaching materials, it has provided a practical and accessible solution for teaching and learning to ski. This has benefited both teachers and students looking to improve their skills as ski instructors.

**KEYWORDS:** didactic tool, mobile app, ski teachers.

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INTERSKI CONGRESS 2023: LEVI Finland; *WORKSHOP 2; Title: ENHANCING TEACHING SNOWSPORT THROUGH DIGITAL TOOLS – SKIEASY MOBAPP, Thursday, 30 March 2023, Hosts: members of SKI EASY partners teams. Venue: Zero Point – slope and Auditorio- Summit*

## CONNECTION BETWEEN PHYSICAL CHARACTERISTICS AND COMPETITIVE PERFORMANCE IN FAST DISCIPLINES OF ALPINE SKIING

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**INTRODUCTION:** In alpine skiing, there is a lot of talk about the relationship between physical preparation, skiing technique and the competitive results of young competitors. It is determined what are the basic parameters of the training of young alpine skiers. This key basic parameter for them is physical preparation as the basis of every preparation of young athletes. During preparation, most of the focus should be based on learning multi-functionality, sport-specific skills and complex movement sequences. These basic parameters should be learned and acquired from the age of 10 to 15. The optimal multidimensional state, which refers to complete involvement - focus on certain tasks and consequently success, leads to many experiential qualities, which refers to the concept of finding these special feelings, especially in the fast disciplines of alpine skiing.

**METHODS:** In this research, we determined the connection between physical characteristics and competitive performance in fast disciplines of alpine skiing, at the age category U16. The sample consisted of 42 competitors (23 boys and 19 girls) between 15 and 16 years of age. In the 2018/19 season, they took part in the autumn measurements at the Faculty of Sport and actively participated in the competition for the Nordica Dobermann Grand Prix in the super-giant slalom. We obtained accurate results of the composition of the competitors' bodies with the Inbody 720 Body Composition Analysis measuring device. For the purposes of our study, we took the following variables: muscle mass fraction, fat mass fraction, body mass index, and body fat percentage. In order to obtain the remaining necessary data, we also used the 3D Body Scan device, which obtained the following variables of body dimensions:

body height, body weight, thigh circumference, waist circumference, chest circumference and shoulder diameter. The criterion for the competitive performance of the subjects was the number of points in the super-giant slalom.

**RESULTS:** In the boys' population, we found a statistically significant association between the variables body weight, thigh circumference, chest circumference and muscle mass fraction, which means that subjects with better results of these measurements are ranked higher in super-giant slalom races. In the girls' population, we found a statistically significant association between the variables: waist circumference, chest circumference, muscle mass shares and body fat percentage, and competition performance. The correlation of the whole model was tested with the help of multiple regression analysis, and we found that in the boys' population, the variables of body composition can explain competitive performance in fast disciplines in 73%, and in the girls' population body composition explains performance in 59%.

**DISCUSSION:** In the research, it was established that the influence of selected variables of body composition on competitive performance in fast disciplines differs according to gender. In the case of boys, it was shown that the following variables: body weight, thigh and chest circumference, and the proportion of muscle mass have the greatest influence on their competitive performance. In the case of girls, the waist and chest circumference, the proportion of muscle mass and the percentage of fat mass in the body have the greatest influence on the competition performance.

**KEYWORDS:** *Alpine skiing, young competitors' performance, motor abilities, anthropometry*

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## THE INFLUENCE OF POLE LENGTH ON UPHILL PERFORMANCE IN SKI MOUNTAINEERING

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**INTRODUCTION:** Ski mountaineering, often referred to as SKIMO, is evolving from a recreational activity to an established competitive sport, especially in light of its inclusion in the upcoming Olympic Games. This research focuses on choosing the proper ski pole length, a crucial element for maintaining stability, coordination, and minimizing effort during the uphill portions of SKIMO. This study investigates how different pole lengths affect uphill performance at different intensity levels, focusing on physiological parameters. The outcomes of this research have the potential to provide important insights that can improve athletes' endurance and optimize SKIMO performance.

**METHODS:** The study involved 12 SKIMO athletes ( $181.6 \pm 5.2$  cm;  $79.8 \pm 9.2$  kg;  $51.3 \pm 4.8$  ml/min/kg). The study consisted of two parts on separate days. In the first part, an SKIMO incremental test was conducted. The test included a standardized warm-up phase of ten minutes at a 20% incline and a 3.4 km/h speed. Following the warm-up, a ramp protocol was initiated with a constant gradient of 24% and a speed of 3.4 km/h, increasing by 0.4 km/h every minute until volitional exhaustion. The second part examined the effects of three different pole lengths (including the optimal length and variations of -5 % and +5%) on physiological parameters such as heart rate, ventilation, oxygen consumption, and oxygen utilization about speed. The incremental test was performed using a K5 metabolic analyzer (Cosmed, Italy) on a treadmill (Rodby, Sweden). The athletes used standard SKIMO

equipment, including the typical pole length. Subsequently, the second part of the protocol involved six distinct performance tests with three different pole lengths at two intensities. Following a 10-minute warm-up, 5-minute exercise bouts interspersed with a 2-minute passive resting phase were conducted for each randomly proposed pole length, targeting low and high intensities.

**RESULTS:** The results showed that there were no significant differences in terms of ventilation, oxygen consumption, heart rate, or efficiency between the different pole lengths tested, both at low (VE ( $p = 0.983$ ), VO<sub>2</sub> ( $p = 0.671$ ), HR ( $p = 0.988$ )) and high intensity (VE ( $p = 0.939$ ), VO<sub>2</sub> ( $p = 0.855$ ), HR ( $p = 0.836$ )).

**DISCUSSION:** The conclusions of the study indicate that SKIMO athletes can choose the length of the ski poles very flexibly, focusing on personal comfort, balance, and adaptation to different types of terrain, without this having a negative effect on the physiological performance indicators. However, the lack of significant physiological differences between different pole lengths could be due to the laboratory conditions of the study, which was conducted on a treadmill with an optimally smooth surface that minimizes slippage and reduces the need for arm support. Consequently, the contribution of pole length to performance under these conditions may be less critical than in real-world environments where uneven terrain requires greater reliance on the poles for balance and propulsion.

**KEYWORDS:** Ski mountaineering, ventilatory efficiency, pole length, uphill.

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## HEART RATE VARIABILITY AS A POSSIBLE STRESS INDICATOR IN RECREATIONAL ALPINE SKIING

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**INTRODUCTION:** Heart rate variability (HRV) is a normal occurrence and should not be confused with arrhythmias or heart rate. Simply, it is the time between heartbeats, and it always fluctuates slightly and can even indicate health or mental health issues. It is accepted that the activity of the autonomic nervous system (sympathetic and parasympathetic) is reflected in the low (LF) and high frequency (HF) bands of HRV. Low frequency usually represents sympathetic activity e.g. stress and is related to a “fight or flight reaction” while high frequency represents the activity of the parasympathetic systems meaning relaxation. The aim of this case study was to explore the possibility of detecting stress situations during an average ski day through HRV.

**METHODS:** The analyzed data was from two experienced skiers who wore a heart rate Polar v800 monitor with HRV function together with a P10 Polar monitor for heart rate (as both functions do not work simultaneously) during the ski day. One subject was more skilled in deep snow and off-slope situations and the other less. The activities were noted in a time diary and contained the type of terrain and type of skiing (off-slope; on-slope; deep snow; rough condition etc.). Also, the perceived feeling of uneasiness and stress felt by subjects were noted. As a measure of HRV, the root mean square of successive R-to-R peak interval differences (RMSSD) was analyzed. Data were analyzed by Polar Flow and Kubios HRV software.

**RESULTS:** The more skilled skier reported only one stressful period in the diary while all other periods were marked as non-stress-provoking. That period was deep snow skiing (off-slope) on a marked route but without good knowledge of what lay below the snow (whether there were small trees, tree wells or other obstacles). The less experienced skier marked three periods as stressful, one already mentioned and another two while skiing the moguls. As only two skiers were involved the results are only by observation: there was an expected increase in

heart rate during and after stressful periods, with a decrease in RMSSD (HRV) in the less experienced skier when compared to non-stressful but also demanding skiing tasks during that day. It was accompanied by an increase in LF and LF/HF ratio during stress-provoking tasks. In the experienced skier there were also some differences but not as notable as in less experienced.

**CONCLUSIONS:** A possibility of using HRV as a biomarker of stress during recreational skiing exists. During stressful periods HRV decreased and low frequency increased, both meaning activated sympathetic system and higher autonomic nervous system stress. This tool might be useful to recreational skiers as higher stress might be related to higher injury risk so an analysis after a ski day might be a good personal indicator about the situations to avoid.

**KEYWORDS:** heart rate variability, HRV, skiing, autonomous nervous system

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## SKELETAL MUSCLE TENSIOMYOGRAPHIC PARAMETERS IN ALPINE SKIERS

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*Presenting author: Boštjan Šimunič*

**INTRODUCTION:** Muscles of alpine skiers do not possess a distinct fiber type composition and, if anything, skiers tend to show a preponderance of slow twitch fibers. This concurs with the recruitment of both muscle fiber types. However, older skiers have higher upper leg muscle torque than younger groups (in males and females) and that is generally dependent on age and biological developmental stage, but this dependence was considerably attenuated when body weight was considered. It seems that leg strength and leg muscle composition are independent factors of alpine skiing performance. Therefore, we aimed to show the correlation of muscle contractile parameters, when estimated from Tensiomyography, are correlated to the age of elite alpine skiers.

**METHODS:** We have assessed 63 elite alpine skiers (21 females), aged between 9 and 32 years. Tensiomyographic parameters (Tc – contraction time; Dm – lateral displacement; Td – delay time) were assessed in ten muscles (VL – vastus lateralis; VM – vastus medialis; RF – rectus femoris; BF – biceps femoris; AL – adductor longus; GL – gastrocnemius lateralis; GM – gastrocnemius medialis; TA – tibialis anterior; GT – gluteus maximus, and ES – erector spinae). We have correlated those parameters with the participant's age. Furthermore, we have compared those who reported their predisposition to speed disciplines or technical disciplines.

**RESULTS:** Although MANOVA revealed sex differences ( $p = .023$ ) in tensiomyographic parameters between sexes, post-hoc analysis could not point out where those differences are. Therefore, we have decided to pool data for correlation analysis. Age was positively correlated with Td in ES ( $r = .34$ ;  $p = .006$ ), GL ( $r = .55$ ;  $p < .001$ ), VL ( $r = .27$ ;  $p = .046$ ) and GT ( $r = .54$ ;  $p = .004$ ). Further, Tc was positively correlated with Tc in GM ( $r = .33$ ;  $p = .020$ ), GT ( $r = .33$ ;  $p = .020$ ), VM ( $r = .36$ ;  $p = .004$ ) and negatively with BF ( $r = -.27$ ;  $p = .035$ ). No correlations were found in Dm. Participants in speed disciplines ( $n = 10$ ) have longer Td in (ES, GL, GT, TA and VL;  $p < .05$ ), longer Tc (VM and GL;  $p < .05$ ) and lower Dm (GT, RF



and TA,  $p < .05$ ) than those of technical disciplines ( $n = 21$  to  $52$ , depending on muscle data availability).

**DISCUSSION:** Out of ten muscles, we have confirmed longer Td in four muscles, longer Tc in three muscles, and shorter Tc in one muscle with increasing skier's age. This could be explained by longer training background in older skiers, as we know that skiing performance strongly relates to the aerobic capacity of the muscles. Skiers in speed disciplines have longer Td in two out of ten muscles and longer Tc in three out of ten muscles as well as higher muscle tone in three out of ten muscles than skiers in technical disciplines. It seems that faster movement frequency in technical disciplines promotes faster muscle fibre phenotypes, which could be supported by lower muscle tone (higher Dm) than in speed discipline skiers.

**KEYWORDS:** Alpine skiing, Tensiomyography, Contraction time.

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## VIRTUAL REALITY IN SKIING: COACHING, SKILL ACQUISITION, AND APPLICATION: A REVIEW

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**INTRODUCTION:** In recent years, there has been significant progress in virtual reality (VR) technology, particularly in the development of immersive virtual environments. With the latest head-mounted displays becoming more user-friendly and cost-effective, sports training can now take full advantage of VR's enhanced operating systems. This allows for the implementation of sophisticated visual simulations and immersive, interactive environments, greatly enhancing the training experience (Šlosar et al., 2022). The rising popularity of VR technology is evident in its influence on various physiological aspects, enhancement of sensorimotor capabilities, replication of critical competition and environmental scenarios for reaction time improvement, and facilitation of skill acquisition. This paper aims to review the current literature on the application of VR technology in the context of skiing, focusing on its role in sports training, skill acquisition, and coaching methodologies.

**METHODS:** We searched three databases (PubMed, Web of Science, and Google Scholar) to identify relevant studies published up to February 2024. The literature reviewed included studies evaluating the effects of different types of VR, such as non-immersive and immersive systems, on the performance of skiing professional and non-professional athletes. Studies involving mixed interventions were excluded from the analysis.

**RESULTS:** Alpine ski training faces challenges posed by environmental limitations and conventional teaching methodologies, which rely on repetitive approaches to skill development. To address these challenges, our research findings will be meticulously presented at the forthcoming congress. We will introduce a range of VR solutions aimed at improving skiers' skills.

**DISCUSSION:** This review explores the potential and limitations of using VR technology to support skiers in their learning process. VR environments provide a unique advantage by facilitating smooth transitions between diverse tasks, thus overcoming environmental

barriers with ease. Such versatility holds promise for revolutionizing ski training methods and optimizing skill acquisition among athletes.

**KEYWORDS:** Virtual reality, exergames, ski simulator, skills development

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## TENSIOMYOGRAPHIC CONTRACTILE PROPERTIES OF SKELETAL MUSCLES OF YOUNG ALPINE SKI RACERS

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*Presenting author: Kaja Teraž*

**INTRODUCTION:** The differences between the sexes become more pronounced during adolescence, which has a particular impact on participation in sport. Scientifically, the differences in biological maturation affect the physiological performance of adolescent ski racers. Tensiomyography (TMG), a non-invasive technique, measures skeletal muscle contractile properties in isometric conditions. TMG-derived parameters, like contraction time (Tc), delay time (Td) and maximal displacement (Dm), correlate with intrinsic muscle characteristics. Previous studies indicate that TMG parameters are related to chronological and biological maturation stages in youth athletes and provide insights into the relationship between puberty, sex differences and muscle characteristics. The purpose of this study was to assess the possible association between body height and muscle contractile properties in developing alpine skiers.

**METHODS:** In the analysis, we included youth Slovenian alpine racers. Using multiple regression analysis, we test the association of body height (after controlling for sex) with TMG parameters (Td, Tc and Dm) in five muscles (biceps femoris - BF, erector spinae - ES, rectus femoris - RF, vastus lateralis - VL, vastus medialis - VM).

**RESULTS:** A total of 43 youth alpine racers ( $168.8 \pm 13.9$  cm,  $63.6 \pm 15.7$  kg,  $15.3 \pm 2.5$  years) with an age range of 9 - 18 years were included in analyses. It was found that body height, after adjusted for sex, significantly predicted Td for Biceps Femoris ( $R^2 = .148$ , (2,40) = 3.461,  $p = .041$ ) and rectus femoris ( $R^2 = .160$ , (2,36) = 3.436,  $p = .043$ ). Furthermore, body height, after adjusted for sex, significantly predicted Dm for erector spinae ( $R^2 = .454$ , (2,40) = 16.646,  $p < .001$ ), rectus femoris ( $R^2 = .302$ , (2,36) = 7.770,  $p = .002$ ), vastus lateralis ( $R^2 = .272$ , (2,40) = 7.467,  $p = .002$ ) and vastus medialis ( $R^2 = .370$ , (2,40) = 11.758,  $p < .001$ ).

**DISCUSSION AND CONCLUSIONS:** In this cross-sectional exploratory study, we found that higher body height is associated with higher Dm in

four out of five muscles, explaining 27.2 to 45.4 % of Dm variance, and higher Td in two out of five muscles, explaining 14.8 to 16.0 % of Td variance. There was no association of body height with Tc. Higher posture yields longer muscle fibers and longer Td could indeed be expected. Whereas longer muscle fibers could also be reflected in higher Dm which could be interpreted as lower muscle stiffness (or tone). Further research that includes maturity status as a peak height velocity, could help young skiers and their coaches to select competition categories.

**KEYWORDS:** muscle properties, posture, youth sport, alpine skiing.

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## THE EFFECT OF EXPERIMENTAL TRAINING IN BUILDING ALPINE SKI SKILLS IN THE "BULGARIAN SKI SCHOOL"

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**INTRODUCTION:** In the global context of skiing, discussions about ski training methods are the subject of ongoing academic and practical debate. Concepts for easier and more accessible training have been introduced, attention has been paid to safety and the acquisition of ski skills, and more recently, digital forms have intervened in hands-on training and personalization of the student's learning path. Research efforts focus on achieving optimal outcomes in the learning process. "Bulgarian Ski School" actively participates in world scientific and professional events, unites professional experience in ski training with scientific and research organizations, and tries to improve the quality of training. In the project concept, we present the methodology of training in alpine skiing technique for beginners based on a pedagogical experiment, the transfer of natural human coordination in alpine skills, the specifics of ski equipment, and others.

**METHODS:** We used a pedagogical experiment and mathematical-statistical methods during the study.

**RESULTS:** Experiential training improved: more accessible adaptation to ski equipment; beginners, trained to a basic turn without folding and unfolding, better master posture, balance, and change of direction; guided exercises build correct movements that improve ski control in turn. New training based on natural human coordination made alpine skiing coordination easier to master.

**CONCLUSION:** Experimental training significantly improved several critical aspects of acquiring alpine skiing skills. These positive results represent a significant advance in developing practical educational approaches for beginning skiers that impact their abilities and confidence in the piste.

**KEYWORDS:** experiential learning, alpine skiing skills, facilitated guidance, beginner skiers.

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## ***PROFESSIONAL ABSTRACTS***



## ACQUIRING AND CONSOLIDATING KNOWLEDGE THROUGH A DIDACTIC GAME – FROM DARING HOPES TO MASTERING THE SLOPES

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**INTRODUCTION:** This paper presents the educational didactic game "From daring hopes to mastering the slopes", developed at the Centre for School and Outdoor Education. This game was designed to help students and skiers learn about FIS rules, Slovenian ski safety law and piste signs in an easy and fun way. Awareness of the rules and correct behaviour on the slopes increases safety and reduces accidents. The best time to play the game is in the run-up to a skiing session. It can also be used in preparation for an outdoor winter school.

**METHODS:** The game is played by 2 to 6 players simultaneously. One of the players is the "controller". The other players are the "skiers". The game is played in conversation. Therefore, there should be no more than 25 students in the room. The game consists of a game mat, game pieces (coloured pieces), dice, question cards, question and answer sheets, rules and instructions for the teacher or game master.

**RESULTS:** The game is mainly used in Centres for School and Outdoor Education. However, it can also be used in primary schools and in the training of future teachers and instructors. All skiers and those who want to learn to ski will also find it useful. The game is designed to help teachers who are preparing to teach skiing to their pupils, or for experienced skiers who want to test their knowledge of the FIS rules of behaviour on the slopes and Slovenian ski safety law.

**DISCUSSION:** At the Centre for School and Outdoor Education, we are constantly striving for quality and innovation in ski teaching. In addition to the educational films by Snežana Jug and Aleksej Kuzmin on learning to ski and ski preparation, the game "From daring hopes to mastering the slopes" is a contribution to improving the quality of teaching alpine skiing.

**KEYWORDS:** alpine skiing, educational game, didactic game, rules, piste signs.

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## DIDACTIC FILMS AS INNOVATIVE TOOLS IN TEACHING ALPINE SKIING

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**INTRODUCTION:** Within the Centre for School and Outdoor Education we have produced three didactic films, namely, “Together on Skis”, “Together for Ski Service” and “Together Through the Methodology of Alpine Skiing “. The films are intended for pupils and especially for teachers who teach alpine skiing.

**METHODS:** Based on extensive knowledge and experience, we have established that through the use of innovative tools, such as a video presentation, we can facilitate more accessible and higher-quality learning of alpine skiing for both students and teachers. By previewing the films students and teachers can see the working process on the snow before actually heading to the slopes. The films place a significant emphasis on the principles of systematic and gradual teaching of alpine skiing. The film “Together on Skis” mostly emphasises the initial forms of skiing and learning how to use ski lifts. The film “Together for Ski Service” instructs us about the importance of preparing alpine skis and equipment. The film “Together Through the Methodology of Alpine Skiing“ is divided into four parts, each clearly illustrating suitable terrain, objectives, techniques, particularities and exercises. The demonstrated set of exercises enables teachers to instruct alpine skiing quickly, safely, and on a high-quality level. This film is the first of its kind in Slovenia which focuses on the systematic and analytical approach of learning alpine skiing.

**RESULTS:** The films are utilised as teaching tools in Centres for school and Outdoor Education, at schools, and at the Faculty of Sports together with all the pedagogical faculties throughout Slovenia, where they are considered obligatory literature for students. The films are freely accessible online.

**DISCUSSION:** The article also highlights the role of the Centre for School and Outdoor Education in skiing literacy for children as well as the purpose and the production process of the educational films.

**KEYWORDS:** alpine skiing, didactic films, innovativeness.

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## THE HISTORY OF SKI INSTRUCTORS

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**INTRODUCTION:** The category of ski instructors boasts one hundred and fifty thousand members in its ranks worldwide, often with a discrete generational and social stratification; a group that has developed its own self-image, slang, and peculiar customs, even a form of shared common memory. In short, ski instructors have their own culture and history, which is worth investigating and recounting.

**METHODS:** The aim of this study is to critically examine the history of ski instructors, questioning both written and oral sources in relation to the main historical junctures. The research follows a chronological thread of events, tracing the history of skiing from its origins to the 2nd World War, gradually introducing its pioneers, the first instructors and the evolution of the discipline, especially in the Italian Alps.

**RESULTS:** For almost 10.000 years, skiing was exclusively a specific form of transport in snow contexts, which has spread in alternating speeds over centuries throughout the entire world. Its main use was for hunting, road transport and warfare. Only in the late 19th century it did take a sporting connotation, imposing itself as the driving discipline of winter tourism only in the 1930s. The function of ski instructors, which appeared historically between these two recent phases, was to link the various economic assets of the mountains to the traditional sporting world.

**DISCUSSION:** Nowadays, climate change and globalization are reshaping the socio-economic profile of mountain environments, raising the question of the sustainability of skiing. Moreover, the mass winter tourism, a substantial urban system, linked through ski facilities and slopes, requires to be managed, especially when it comes to safety and accident prevention. Just like driving schools in cities, ski instructors teach users to move safely in the snow environment. Therefore, it is worth questioning whether a return to its historical roots as a means of transport, even before its sports and leisure dimension, might represent its true key to the future.

**KEYWORDS:** ski as a transport and sport, the role of skiing in the World Wars, the roots of winter tourism.

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## SKI HARD – NO BASE NO RACE

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**INTRODUCTION:** SKI HARD – NO BASE NO RACE is an upgrade of basic alpine skiing training, which is set up as a Ski Easy project. The aim of the project is to increase the number of children who are enthusiastic about alpine skiing from a young age. We want to build on the skills of young skiers who can make coordinated turns on parallel skis by increasing the speed and movement required to ski in a confined space and in a giant slalom set-up. The ultimate goal is to achieve high quality turns in rhythmic and situational giant slalom set-up. The number of skiers in Slovenia is small, which is why the Alpine School programs are very popular in clubs and ski schools. In these programs, they try to inspire children for competitive skiing through different set-ups and skiing in a confined space.

SKI HARD – NO BASE NO RACE is a method designed to help participants master carving skiing in free skiing and in a confined space, which is essential for quality competitive turns. By giving the skiers guidelines and rhythms, we guide them through the correct sequence of movements necessary for a better technical execution.

In free skiing, both basic and wide corridor turns are intertwined on different slopes and at different speeds. Basic swinging is practiced developing combined ski control at low speeds, which is then improved by increasing speed and transitioning to carving turns. Wider corridor is performed exclusively through carving techniques, with a methodical progression from basic swinging to unconnected turns. The objectives that a skier needs to master before they can start to limit the space are the sense of space, speed control and skiing positions.

**METHODS:** We use a variety of methodical set-ups to transfer quality ski technique from free skiing to a confined space. Methodical set-ups require a variety of equipment, from brooms, low rubber pegs, to large stakes and giant slalom gates. Commonly used are corridors, carving corridors, simulated turns with gradually decreasing number of directional markers and combinations of poles and brooms, low rubber poles and giant slalom gates. When training on low markers such as poles and brooms, various exercises with or without poles can be included. The

most useful exercises for practicing low mark technique include airplane, superman, poles held in a tight grip in front of the eyes, straitjacket and lifting the inside ski before starting the turn.

**RESULTS:** By gradually introducing and adapting the skier to the limited space, skiers are getting for skiing in a giant slalom set-up. At the same time, we want to build up the skier's knowledge to the highest possible level, which would be more difficult in pure free skiing. The focus is on modern competition techniques with carving skiing to increase both speed and the speed barrier with the progress of the skiing technique.

**DISCUSSION:** With the existing pool of skiers, the aim is to inspire as many of them as possible and give them a broader skiing knowledge on organized slopes in a limited space, which offers them the basis for further development as a skier toward competitive skiing.

**KEYWORDS:** free skiing, ski technique, limited space, skiers.

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## ANALYSIS OF FIFTEEN YEARS OF SITSKI DEVELOPMENT CAMP IN SLOVENIA

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**INTRODUCTION:** The Slovenian Association of Paraplegics in cooperation with the Paralympic Committee of Slovenia is an annual organizer of the sitski development camp for people with spinal cord injuries. The camp has been organised since 2009. It takes place in a Slovenian ski resort, which can provide facilities for wheelchair users and shows great support and acceptance for para-alpine skiers on slopes. Every year people with spinal cord injuries come back to improve their skiing knowledge, maintain skills and physical fitness and be part of the skiing society. The number of participants depends on the economic and health status of the participants, the weather conditions and promotion quality in local organisations. Social networks prove to be crucial, as it is very common, that a new participant comes on invitation from another person with a disability, who had a positive experience at the sitski camp.

**METHODS:** We have collected data about participants in sitski camp since 2009 and made basic statistics. We were most interested in how a promotion of the camp affected on development of para-alpine skiing.

**RESULTS:** Overall, 55 different people have attended the camp since 2009 at least once, making a total of 268 participants. When the camp first started, 30 % of participants could already ski and 70 % were beginners. Nowadays the numbers are reversed. There are only 15 % of female sitski skiers recorded in all ten years (10 females out of 55 participants). The youngest participant was 8 years old when she first attended the camp. In 2014 the camp became international with guests from Croatia and Bosnia and Hercegovina. Every year there was a minimum of 3 new participants, the most massive participation was in 2010, when there were 15 fresh sitski skiers and again in 2014 with 10 new ones. The camp was not performed in 2021 due to Covid-19 restrictions and has come back even stronger with over 20 participants in the following years.

**DISCUSSION:** Teaching para-alpine skiing follows the national skiing school system with additions that are specific to para-alpine skiing. We

start with initial forms of skiing (transferring from wheelchair to sitski, adapting to equipment and snow, warming up, teaching how to fall and get up, sliding, stopping) followed by the basic forms of skiing (basic individual turn, series of turns in one direction, basic connected turns and using ski lifts). Skiers who master basic skiing techniques are ready to start with dynamic turns on the edge. We give great importance to providing a good experience in order for our participants to feel safe and have fun on the slopes and consequently become recreational para-alpine skiers.

**KEYWORDS:** para-alpine skiing, development camp, spinal cord injury

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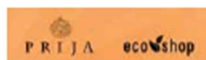
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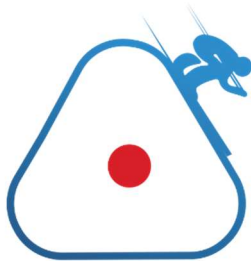


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