7 th INTERNATIONALCONGRESS ON SCIENCE AND SKIING. 2016.

St. Christoph a. Arlberg. Ski Austria Academy

7th INTERNATIONAL CONGRESS ON SCIENCE AND SKIING

Programa de Becas Mujer y Deporte. CSD – RFEDI

SPAINSNOW
REAL FEDERACIÓN ESPAÑOLA DEPORTES DE INVIERNO

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CONTENIDOS

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1. INTRODUCCIÓN

El 7º Congreso Internacional de Ciencia y Esquí 2016, tuvo lugar en Austria, en St. Christoph a. Arlberg, del 10 al 15 de diciembre. Se organiza cada 3 o 4 años, siendo este el 6º organizado en St. Christoph a. Arlberg junto a los de 1996, 2000, 2007, 2010 y 2013, ya que el de 2004 se organizó en Aspen, USA.

El congreso lo organiza cada año el Departamento de Ciencias del Deporte y Kinesiología de la Universidad de Salzburgo. Su máximo responsable es Eric Müller, que cuenta con más de 22 miembros del comité científico, de diferentes países y 17 profesores de la Universidad de Salzburgo, que colaboran activamente en la organización del Congreso.

El programa científico ofreció un amplio espectro interdisciplinario de los trabajos actuales de investigación en esquí alpino, esquí de fondo y en snowboard. Científicos bien conocidos internacionalmente, procedentes de diferentes países, presentaron sus descubrimientos científicos en presentaciones orales o en pósters.

Además del trabajo científico, se realizaron varias actividades sociales que ofrecían una buena oportunidad para hacer networking e intercambio de ideas.

2. DESCRIPCIÓN DE LAS INSTALACIONES

El congreso se celebró en St. Christoph en las instalaciones de Ski Austria Academy que cuenta con las siguientes infraestructuras disponibles para el congreso:

- Hall Recepción del Hotel: Esta instalación se utilizó para diferentes actividades como presentación oral de póster, coffee break, cóctel de bienvenida.
- Habitaciones individuales, dobles y triples.
- Cafetería.
- Comedor: Auto servicio con diferentes platos de comida caliente, bufet de ensaladas, de postres y bebida. En la que se hacía el desayuno, comida y cena.
- Una tienda pequeña, con merchandising y cosas de higiene personal.
- 1 Sala de recepción del congreso: Para todos los trámites y consultas con la organización del congreso. En la cual se hacía la confirmación de llegada, entrega del programa y de los forfaits para la visita guiada a la estación.
- 1 Sala de exposición de novedades de material: Diferentes sponsors y marcas de material exponían sus novedades. Entre los que se encontraban:
    - SIMI: Exponían sus sistemas de análisis de movimientos http://www.simi.com/en.html
    - Ski-mojo: http://www.simi.com/en.html
    - Moticon: En su espacio mostraban el funcionamiento y usos de sus plantillas, las cuales miden la pisada en el movimiento. http://www.moticon.de/

- 1 Sala pequeña de presentaciones orales "seminar Room": En la cual se realizaban presentaciones orales cuando se duplicaban o coincidían 2 bloques de presentaciones.
- 1 Anfiteatro o "Lecture Hall": Con capacidad de aproximadamente unas 400 personas. Donde se hicieron, como sala principal, la mayoría de las presentaciones orales, presentación de parte de los pósters, la entrega de premios y la ceremonia de clausura.
- 1 Ski-room: Espacio dotado con taquillas para guardar el material de esquí, con salida directa a la pista.

3. PROGRAMA CIENTÍFICO

El programa científico del Congreso se compuso de:

- 4 Keynote Sessions: Sesiones orales de 45 a 60 minutos en las que se expusieron los siguientes estudios de investigación:
    - Sábado 10 de diciembre de 18 a 19h: Concentraciones excéntricas, isométricas y concéntricas: ¿Cuál es la dominante en esquí alpino? *Minetti Alberto et al.* (Universidad de Milan).
    - Domingo 11 de diciembre de 8 a 8:45h: ¿Son los esquís culpables de los altos ratios de lesiones en esquí alpino? *Supej Matej et al* (Universidad de Ljubljana)
    - Lunes 12 de diciembre de 8 a 8:45h: Biomecánica y fisiología del esquí nórdico. *Thomas Stöggl et al.* (Universidad de Salzburgo).
    - Martes 13 de diciembre de 8 a 8:45h: Esquí Alpino y Salud cardio-metabólica. *Dela Flemming et al.* (Universidad de Copenhague).

- 18 Sesiones Orales con un total de 93 presentaciones:
    - Domingo 11 de diciembre de 8:45 a 10:15h: HIT – En memoria a Michi Vogt. De 3 presentaciones de 30 min:
        - Moderate Load Eccentric Exercise. *Hoppeler Hans et al*.
        - The Challenge of Training for Strength and Endurance. *Gross Micah et al.*
        - Hit training – 15 years of experience. *Helgerud Jan et al.*
    - Domingo 11 de diciembre de 10:45 a 12:00: XCS y Biathlon. De 5 presentaciones de 15 min:
        - Comparison between cross-country skiing on snow and roller skiing on treadmill with the same track profile. *Ruostekoski Anni et al.*
        - Analysis of sub-techniques in classical cross-country skiing by employing machine learning algorithms on micro-sensor data. *Rindal Ole Marius Hoel et al.*
        - Classification of Ski Skating Techniques using the Head's Trajectory for use in GNSS Field Applications. *Gløersen Øyvind et al.*
        - Heart rate profiles, external work rate and kinematics when ski skating on varying terrain during low-, moderate-, and high-intensity endurance training. *Haugnes Pål et al.*
        - GPS and heart rate based analysis method for high level biathlon competitions. *Kocbach Jan et al.*
    - Domingo 11 de diciembre de 17 a 18:45h: Esquí Paralímpico. De 7 presentaciones de 15 min:
        - Performance and perturbation tests in elite paralympic sit-skiers. *Rosso Valeria et al.*

        - Determination of the second lactate threshold in Norwegian ice sledge hockey players during upper-body poling. *Baumgart Julia et al.*
        - A systematic race course analysis and a description of men's race performance in Paralympic alpine skiing World Cup Slalom and Giant Slalom races of the seasons 2014/15 and 2015/16. *Bruhin Bjoern et al.*
        - External forces in alpine sit-skiing vs. athletes' strength abilities – consequences for development of evidence-based classification. *Goll Maren et al.*
        - Fair, equal, safe and universal equipment in parasports - experiences from development of a sit-ski and lower leg prosthesis for Cross Country skiing. *Danvind Jonas et al.*
        - Kinematic and kinetic analysis of a paralympic skier during slalom. *Petrone Nicola et al.*
    - Lunes 12 de diciembre de 8:45 a 10:15h: Esquí Alpino. De 6 presentaciones de 15 min:
        - Influence of upper body anaerobic pre-load exercise on energy metabolism and performance in an alpine ski-specific box-jump test. *Sieder Mario et al.*
        - Injuries and illnesses in elite youth alpine ski racers and the influence of biological maturity and relative age: a two-season prospective study. *Müller Lisa et al.*
        - Ski turn kinematics: a comparison between downhill skiing and training on skiing simulators. *Woznica Wojciech et al.*
        - Comparative electromyography analysis of skiing on slope and in simulating conditions. *Szymanska Dominika A. et al.*
        - Development of a new 6 component force sensor design for biomechanical research in alpine skiing. *Falda Thomas et al.*
        - A fundamental study on deformation behavior of ski and snow surface. *Hashimoto Yuto et al.*
    - Lunes 12 de diciembre de 10:45 a 12:15h: Optimización del rendimiento en deportes de invierno. De 4 presentaciones de 20 min:
        - Event preparation in 'middle-distance' events: making practical sense of pre-conditioning and priming the body for competition day. *Pringle et al.*
        - Minimal and non-invasive monitoring of the training and health of elite athletes using commercially available wearable and point-of-care technology. *Sperlich Billy et al.*
        - Muscle fatigue during high-intensity exercise – an update. *Ortenblad Niels et al.*
        - Frequency effects in cross country skiing - biomechanical and physiological aspects. *Lindinger Stefan et al.*
    - Lunes 12 de diciembre de 13:30 a 14:45h: Análisis del rendimiento en Esquí Alpino. De 5 presentaciones de 15 min:

    - Predictors of instantaneous performance in alpine giant slalom – how to best solve the permanent trade-off between shortening the path while maintaining speed? *Spörri Jörg et al.*
    - Alpine ski racing gate crossing detection using magnetometers. *Fasel Benedikt et al.*
    - Performance time profiling of elite GS and SL alpine skiers. *Spencer Matt et al.*
    - Performance analysis of FIS alpine WC-races (SL, GS) from season 11/12–15/16 concerning course setting and slope characteristics. *Huber Andreas et al.*
    - Variations of the relative age effect within and across groups in elite alpine skiing. *Bjerke Øyvind et al.*
  - Lunes 12 de diciembre de 15:15 a 16:45h: Biomecánica en XCS. De 6 sesiones de 15 min:
    - Mechanical energy and work in treadmill double poling on roller skis. *Danielsen Jørgen et al.*
    - 3d kinematic of lower limbs in freestyle cross country skiing (XCS) technique during WC (Dobbiaco 2012) and wchs (Fiemme 2013). *Canclini Arrigo et al.*
    - Comparative 3d kinematic and dynamic analysis of diagonal stride in elite backcountry skiing (skialp) and cross country skiers. *Pozzo Renzo et al.*
    - A portable post-processed kinematic GNSS receiver for advanced ski measurements. *Miyamoto Naoto et al.*
    - The use of a smartwatch to analyze the modern interpretation of marcialonga xc-ski race. *Bortolan Lorenzo et al.*
    - Using a real-time location system to track and analyze performance in cross-country skiing. *Swarén Mikael et al.*
  - Martes 13 de diciembre de 8:45 a 10:15h: Saltos de Esquí y otros deportes. De 6 presentaciones de 15min:
    - The effect of jump design on rider kinematics and reaction forces in snowboarding – a methodological study. *Wisser Anne et al.*
    - Accurate temperature measurement of interface between ski and snow surface for frictional heating evaluation. *Okajima Junnosuke et al.*
    - Posture optimization of ski jumper for better aerodynamic performance: 1. Experiment. *Bang Kyeongtae et al.*
    - Posture optimization of ski jumper for better aerodynamic performance: 2. Simulations. *Kim Woojin Kim et al.*
    - Static and dynamic characteristics of jumping skis. *Gim Jinsu et al.*
    - Experimental investigation of ice friction reduction using micro-structures for jump ski plates. *Kim Sangmyeong et al.*
  - Martes 13 de diciembre de 8:45 a 10:15h: Psicología y Pedagogía. De 6 presentaciones de 15 min. (Seminar room):
    - Relationship of mental skills and cognitive performance parameters within alpine skiers, soccer players and martial artists. *Amesberger Günter et al.*

    - Inhibition and working memory of alpine skiers, soccer players and martial artists. *Finkenzeller Thomas et al.*
    - The flow experience in alpine skiing. *Brandauer Thomas et al.*
    - Flow and performance during race-like alpine giant slalom skiing. *Bernatzky Patrick et al.*
    - Constraints led approach improves available time of practice in alpine ski learning. *Figueiredo Sérgio et al.*
    - Differences in demonstration of alpine ski school elements. *Žvan Milan et al.*
- Martes 13 de diciembre de 10:45 a 11:50h: Métodos en esquí alpino. De 2 presentaciones de 15 minutos y 2 presentaciones de 20 minutos:
    - The point of force application during the turn and its meaning for science in skiing. *Senner Veit et al.*
    - Imu and gnss-based turn switch detection in alpine ski Racing. *Falbriard Mathieu et al.*
    - Understanding ski glide test data – acquisition and interpretation. *Kirby Richard et al.*
    - Investigations of fundamental processes in ski-snow friction. *Lüthi Anton et al.*
- Martes 13 de diciembre de 10:45 a 12:00h: Saltos de esquí y otros. De 5 presentaciones de 15 min. (Seminar room):
    - Considerations and challenges of biomechanical performance diagnostics in ski-jumping. *Schwameder Hermann et al.*
    - The development of potentional performance in ski-jumping from the morphological and motoric aspect. *Jost Bojan et al.*
    - Computation of ground reaction forces in ski jumping imitation jumps based on inverse dynamics. *Fritz Julian et al.*
    - Relationship of squat jumps, imitation jumps and hill jumps in ski jumping from a biomechanical perspective. *Lorenzetti Silvio et al.*
    - Tensiomyography as a method for preventing injuries at alpine skiers. *Pišot Rado et al.*
- Miércoles 14 de diciembre de 8 a 9:45h: Alta calidad XCS. De 6 presentaciones de 15 min:
    - Energy contributions and pacing strategies of elite cross-country skiers during sprint skiing. *Andersson Erik et al.*
    - Do cross-country skiing competitions demand the same from male and female skiers, and what is the importance of the upper body on the gender differences? *Hegge Ann Magdalen et al.*
    - Can altitude training be recommended for elite athletes. *Lundby Carsten et al.*
    - Why do the best cross-country skiers perform so many hours of low-intensity training? *Sandbakk Øyvind et al.*
    - Considerations on the cost of transport in cross-country skiing. *Herzog Walter et al.*
    - Exercise intensity and pacing strategy of cross-country skiers during a simulated 10-km skating race. *Thomassen Tor Oskar et al.*

        - Vo2peak in v2 roller skiing and uphill running with poles in elite xc skiers. *Hynynen Esa et al.*
    - Miércoles 14 de diciembre de 10:15 a 11:45h: Equipación en esquí alpino. De 5 presentaciones de 15 min:
        - Ski bindings, inadvertent release, and ACL injuries. *Brown Christopher A. et al.*
        - Ski binding loads generated during alpine skiing and alpine touring skiing: a comparison of the retention requirements. *Campbell Jeffrey et al.*
        - Design of skis with non-tailored snow interaction. a reverse commercial approach. *Sancho Jose et al.*
        - Does ski width influence muscle activity and ski actions in an elite skier? a case study. *Seifert John et al.*
        - 3d printing of ski boots structural parts: comparison of printing methods and materials. *Colonna Martino et al.*
    - Miércoles 14 de diciembre de 10:15 a 11:45h: Esquí Paralímpico 2. De 6 presentaciones de 15 min. (Seminar room):
        - The conceptual framework of evidence-based classification applied to nordic skiing for athletes with intellectual impairment. *Vanlandewijck Yves et al.*
        - Optimization of paralympic winter sports performance. *Perret Claudio et al.*
        - Development of a classification protocol for paralympic sit-skiers. *Rapp Walter et al.*
        - Sports engineering and biomechanical aspects of cross-country sit-skiers. *Gastaldi Laura et al.*
        - Evaluation of two sitting positions in cross-country sit-skiing. *Lund Ohlsson Marie et al.*
        - Tribological optimization of sit-skis. *Scherge Matthias et al.*
    - Miércoles 14 de diciembre de 13:30 a 14:45h: Prevención de lesiones en esquí alpino. De 5 presentaciones de 15 min:
        - Changing the ski regulation to protect the athlete's knee: what was the justification? what do the data tell us? what did we learn? *Kröll Josef et al.*
        - Can we predict where accidents occur on world cup alpine ski racing courses? *Gilgien Matthias et al.*
        - Adapting a school-based injury prevention program to reduce injury risk in youth alpine racers: a pilot study. *Doyle-Baker Patricia (Tish) et al.*
        - Dynamics of snow park jump landings: a pilot study examining impact loads. *Scher Irving et al.*
        - The effect of ski boot flexion stiffness on jump landings in skiing. *Kurpiers Nico et al.*
    - Miércoles 14 de diciembre de 15:30 a 16:45h: Fisiología de XCS. De 5 presentaciones de 15 min:
        - Skiing efficiency in world-class distance-specialized and sprint cross-country skiers. *Vesterinen Ville et al.*

        - On the effects of upper-body sprint-interval training on maximal strength and aerobic power in female cross-country skiers. *Welde Boye et al.*
        - Influence of pole lengths on o2-cost and 3d kinematics in double-poling: flat vs. Uphill. *Losnegard Thomas et al.*
        - Effects of acute nitrate supplementation during cross-country roller-skiing in normobaric hipoxia. *McGawley Kerry et al.*
        - Should we be afraid of lactate? beneficial effects of elevated blood lactate concentration on high-intensity exercise performance. *Hofmann Peter et al.*
    - Miércoles 14 de diciembre de 15:30 a 16:30h: Esquí cross y esquí alpino. De 4 presentaciones de 15 min. (Seminar room):
        - Start performance in ski cross and snowboard cross: influence on race results and kinematic and kinetic analyses. *Spitzenpfeil Peter et al.*
        - Start performance in ski cross: kinematic and kinetic analysis. *Olvermann Matthias et al.*
        - Start performance in snowboard cross: kinematic and kinetic analysis. *Frühschütz Hannes et al.*
        - Visual inspection of skiing course and terrain using virtual and augmented environment. *Khlamov Maxim et al.*
    - Miércoles 14 de diciembre de 17:15 a 18:15h: Fisiología y acondicionamiento en esquí alpino. De 4 sesiones de 15 min:
        - Simulated ski specific shocks - impact on force, time and knee angle parameters: a pilot study. *Raschner Christian et al.*
        - Associated pathology and limb asymmetry in ACL reconstructed elite alpine racers. *Jordan Matthew et al.*
        - Microvascular oxygen extraction during competitive alpine skiing with regard to loaded and unloaded phases. *Stöcker Fabian et al.*
        - Redistribution of lower extremity joint moments during alpine skiing. *Decker Michael et al.*

- 3 Bloques de presentaciones de Póster con 44 presentaciones de Póster:
    - Seminar room: 17 presentaciones de Póster:
        - Rehabilitation following ACL-reconstruction in alpine ski racing – can indoor carpet skiing build the bridge between ski-specific off-snow training and return-to-ski? *Spörri Jörg et al.*
        - Injury as opportunity. return to sport after ACL reconsctruction in youth, non-elite alpine ski athletes. one on-snow integrated protocol. a case study. *Elena Bettega et al.*
        - Do ACL injured female and male recreational skiers differ regarding ski length to height ratio, ski length to weight ratio and sidecut radius? *Ruedl Gerhard et al.*
        - Health status of Japanese masters skiers - comparison with the general population in japan. Yamane Maki et al.
        - Leg and trunk strength training in alpine ski racing – comparison of three squat exercises under isokinetic conditions. *Huber Andreas et al.*

- Leg and trunk strength training in alpine ski racing – comparison of traditional with isokinetic trunk training. *Huber Andreas et al.*
- Comparison of standard and newer balance tests in recreational alpine skiers and non-skiers. *Cigrovski Vjekoslav et al.*
- How do custom made insoles affect the pressure distribution under the feet in alpine skiing? *Swarén Mikael et al.*
- A new six component force plate for measuring ground reaction forces in alpine skiing. *Nakazato Kosuke et al.*
- Design of novel sensors to measure all components of ski and snowboard force and torque. *Campbell Jeffrey et al.*
- The measurement of forces acting on a skier during slalom turns. *Tsunoda Kazuhiko et al.*
- The measurement of forces acting on the skier during continuous turns. *Sasaki Tsutomu et al.*
- Developemt and evaluation of a suspended binding plate for alpine skiing. *Wolfsperger Fabian et al.*
- The effect of bench, prosthesis, speed and test method on the flexural behaviour of ski-boots. *Petrone Nicola et al.*
- Proposed test method for measuring dynamic-impact forward-retention characteristics of ski bindings. *Howell Rick et al.*
- Measurement of ski and snow board turns using two different gps devices. *Takeda Tadashi et al.*
- 3d kinematics analysis for inside leaning motions in alpine skiing. *MIURA TETSU et al.*
- Iliotibial (it) band function in counter-rotation ski turns. *Kirchhoff Tommy et al.*

- Anfiteatro o Lecture Hall: 14 presentaciones de Póster:
  - Comparison of the test-retest reliability of physiological parameters during closed-end and incremental upper-body poling tests. *Baumgart Julia et al.*
  - Maximal oxygen uptake in double poling vs. running in high-level cross-country skiers. *Kjæreng Winther Andreas et al.*
  - Contribution of arm swing on the kinematics and energy characteristics of v2a ski skating in elite cross-country skiers. *Bessone Veronica et al.*
  - A numerical study on the effect of ski vibration on friction. *NAM YUN HYOUNG et al.*
  - The influence of the size of the base of support on the skier's basic stance and downhill body position. *Woznica Wojciech et al.*
  - Comparison of movement patterns between skiing on an indoor skiing carpet and on snow. *Bruhin Bjoern et al.*
  - A ski racer's turn cycle structure depends on slope inclination, speed and gate offset. *Falbriard Mathieu et al.*
  - The difference of flow experiences between skiers and snowboarders in japan. *SAKATANI Mitsuru et al.*
  - Cleanness of triggering is related to biathlon standing shooting performance. *Ihalainen Simo et al.*

- Improving ski jumping performance: optimization of ski angles in the flight phase. *Petrat Johannes et al.*
- Validation of wearable sensors to measure acceleration of landing impacts. *Ross Cameron et al.*
- Cross country skiing experiments for "delight" evaluation by electro-oculography. *Hatakeyama Nozomu et al.*
- Research on time analysis at men's world cup slalom race in Yuzawa Naeba: comparison between world's top racers and Japanese racers. *TAKEDA Tadashi et al.*
- Using telecasting to identify key performance indicators in alpine skiing and evaluate the inter-analyst reliability of alpine ski coaches. *Swarén Mikael et al.*

- Hall de recepción: 13 presentaciones de Póster:
  - Biomechanical differences in double poling (dp) for world- and national-class female elite cross-country (xc) skiers during a 10-km classical race. *Jonsson Malin et al.*
  - Kinematics of world-class and national-class cross-country skiers on an uphill section in a classical race. *Welde Boye et al.*
  - Validation of relative com displacement in v2 skating obtained with inertial sensors – a feasibility study. *Fasel Benedikt et al.*
  - The effect of incline on muscle activity in the v2-technique. *Jensen Randall L et al.*
  - Class-specific biomechanical characteristics of double poling in elite paralympic nordic sit-skiers. *Karczewska-Lindinger Magdalena et al.*
  - Different physiological responses against two different exhaustion tests, pole walking or roller skiing, in highly trained cross-country skiers. *Takeda Masaki et al.*
  - Gender differences in rate of perceived exertion at the first and second lactate threshold during roller skiing. *Skovereng Knut et al.*
  - Pre and post season peak lactate levels during recovery phase in alpine skiers assayed by two test types: wingate and squat rebound jump. *HOSHINO Hiroshi et al.*
  - Lactate kinetics during recovery phase in alpine skiers assayed by two test types: wingate and squat rebound jump. *HOSHINO Hiroshi et al.*
  - European student-athletes' perceptions on dual career outcomes and services in winter sports. *Wagner Herbert et al.*
  - Empathy and emotional regulation of alpine ski and snowboard coaches and the impact on the performance of the athletes. *Pintado Riesco Marta.*
  - Teaching program of skiing for elementary school teachers. *Takeda Tadashi et al.*
  - Contribution of inline skating to learning basics of alpine skiing in adult ski beginners. *Cigrovski Vjekoslav et al.*

Los diferentes deportes de invierno que se contemplaron en las investigaciones fueron esquí de fondo, esquí alpino, saltos de esquí, snowboard, esquí paralímpico.

Los principales temas que se trataron en las investigaciones hacían referencia a:

- Técnica: Sobre todo las presentaciones de esquí de fondo, fueron las que trataron aspectos referentes a la técnica. Presentaciones en las que se comparaban las diferentes técnicas y en qué tipos de pista y pendiente eran más efectivas. La mayoría de las ponencias eran referentes al "Double Poling".
  Hubo varios estudios sobre la técnica de salida en Boardercross de snowboard.
- Biomecánica: Enfocados a crear y mejorar dispositivos de medición y registro de movimientos, sobre todo de esquí alpino y alguno en snowboard.
- Preparación Física y fisiología: Comparaciones entre entrenamientos en tapid y en nieve, con máquinas que reproduzcan movimientos específicos, buscando imitar las condiciones de nieve lo más exactamente posible para facilitar entrenamientos específicos en interior. La mayoría de estudios referentes a esquí alpino eran en esta línea de preparación física, dirigidos sobre todo a prevención de lesiones. Los estudios de fisiología presentados, estaban dirigidos hacia la mejora del rendimiento.
- Material: Las presentaciones de material, estaban enfocadas, sobre todo, a la prevención de lesiones. Analizando por ejemplo la influencia de los tipos y las características de los esquís sobre la tasa de lesiones. Las botas. Estudios sobre las fijaciones, en el que se destacó el coste elevado que supone la mejora de las fijaciones. Y máquinas de 3D para la construcción por ejemplo de piezas para botas.
- Psicología y Pedagogía: Pocos estudios referentes a estos tópicos. Hubo únicamente 6 exposiciones orales, dos de ellas acerca del "Flow" y una sobre metodología de la enseñanza. En formato poster hubo uno acerca de metodología de la enseñanza, y otro sobre la empatía y la regulación emocional del entrenador y su influencia en el rendimiento de sus deportistas.

En la mayoría de los estudios, se ponía de manifiesto la dificultad a la hora de medir variables, sobre todo por los dispositivos de medición. Y la dificultad de reproducir en el laboratorio las condiciones reales propias del deporte (en nieve).

Otra de las dificultades era la muestra de investigación, que normalmente es pequeña. Ya que los deportistas de deportes de invierno, sobre todo de alto rendimiento, son escasos en comparación con otros deportes.

Destacar el mensaje de algunos ponentes que insistían en que, aunque a veces los resultados científicos concluyan en que no hay diferencias significativas, se pueden sacar conclusiones y abrir nuevas líneas de investigación.

Los Abstracts de las investigaciones se pueden encontrar en el anexo y en el siguiente enlace:

https://icss2016.at/index.php?id=101

Cuadro de contenidos relevantes:

PREPARACIÓN FÍSICA. ENTRENAMIENTO ESQUÍ ALPINO
Contracciones concéntricas, isométricas o excéntricas: ¿cuáles son dominantes en el esquí alpino? Alberto Minetti et al. A pesar del aumento de los estudios, aún persiste la incertidumbre sobre qué acciones musculares son dominantes en el esquí alpino. Esta incertidumbre se debe, sobre todo, a la dificultad para analizar la relación entre las diferentes variables fisiomecánicas y aspectos kinestésicos del centro de masa, altitud, trayectoria, velocidad y energía mecánica, durante el descenso. Entender el trabajo de los músculos en el descenso podría ayudarnos a definir mejores sesiones de entrenamiento y a diseñar máquinas específicas para ello. Podemos esperar una gran contribución de contracciones musculares tanto excéntricas, isométricas como concéntricas. En Esquí Alpino hay que tener en cuenta que se aplicaran fuerzas y energías durante el descenso, ya que el ascenso se realiza en telesilla, disipándose inevitablemente esta energía. Por lo que parece que son las contracciones excéntricas las que dominan la acción en el Esquí Alpino. Un estudio de Helmut Gottschlich y Hans Zehetmayer (1978) desafían este concepto. Su modelo muestra que en slalom la energía necesaria es cero, debido a la posición del esquiador en la que sus ángulos y articulaciones pueden mantenerse constantes, por lo que sus acciones musculares serán isométricas. Finalmente, durante el descenso se espera que la energía corporal global disminuya continuamente debido a la fricción de la nieve, lo que perjudica la transformación del potencial en energía cinética del centro de masa corporal. Sin embargo, es posible que en algunos casos (al final de la curva) la velocidad del esquiador aumente más que la disminución de la energía mecánica disponible neta. Este trabajo extra-positivo podría ser proporcionado por alguna contracción concéntrica de la unidad del tendón del músculo que ocurre después de haber sido alargado con fuerza en la fase centrífuga de la curva. Esto podría ser el responsable de alguna ganancia de velocidad activa del atleta. Por lo tanto, como se ha visto anteriormente, nos enfrentamos a una actividad de movimiento donde la energía total necesaria podría ser cero o donde la fuerza muscular podría ser predominantemente excéntrica, isométrica o incluso concéntrica.
Carga moderada del ejercicio excéntrico. Hans Hoppeler et al. Actualmente y desde hace unos años se trabaja frecuentemente los ejercicios excéntricos en ergómetros motorizados, ya permiten la aplicación controlada de cargas excéntricas. Con deportistas de élite se está trabajando a más de 1200W unas tres veces por semana, durante sesiones de 20-30 minutos. Este ejercicio lo hemos denominado “ejercicio excéntrico de carga moderada”. Es distinto de los ejercicios pliométricos que imponen cargas musculares de varios miles de vatios. También es distinto del entrenamiento de sobrecarga excéntrica, por el cual las cargas en un ajuste convencional de entrenamiento de fuerza, se incrementan en la fase excéntrica del movimiento para coincidir con cargas concéntricas. Se ha demostrado que el ejercicio excéntrico de carga moderada es similarmente efectivo al entrenamiento convencional de fuerza para aumentar la fuerza muscular y el volumen muscular. Propone trabajar excéntrico de 3 maneras: ● DROP JUMP: Tiempos de contacto muy pequeños, Pmax suele ser>90 W/KG, hasta 700W en la recepción. ● ECC OVERLOAD: Con 1 o dos piernas, velocidad angular 20-30 º/s, máquinas tipo YOYO. X-force. ● MODERATE LOAD ECC. EXERCISE: ergómetros que regulan la potencia. Máquinas tipo prensa. 3 veces por semana, en concéntrico cadencias 40-80 rpm, en excéntrico no se puede controlar, aunque siempre son mayores de 80 rpm. ● CONC-ECC Puedes cargar hasta 4 veces más tus músculos en excéntrico. El trabajo ideal es 3 veces por semana, 30 minutos. Esto puede suponer una ganancia de diámetro muscular. ● El potencial del entreno excéntrico en esquiadores es muy alto. Con 4 series de 5 min puedes llegar a cargar 240 ton por sesión, v. angular 240 º/s en una cadena cerrada aumentando la carga de la articulación. Sin una máquina específica no podríamos llegar nunca a estas cargas. Este tipo de ejercicio también es efectivo para trabajar afecciones cardiorrespiratorias, cáncer, un tipo de diabetes y afecciones neurológicas. Además de para la rehabilitación de lesiones como la rotura de ligamento cruzado anterior y con personas mayores.

El reto de entrenamiento de fuerza y resistencia. Micah Gross et al.
EL rendimiento deportivo en la mayoría de los deportes aumenta con una buena fuerza y potencia muscular y esto a su vez también ayuda a realizar un entrenamiento de calidad y reduce el riesgo de lesión a pesar de la fatiga, especialmente en deportes no cíclicos. También se requiere, en casi todos los deportes, un buen nivel de acondicionamiento aeróbico para alcanzar un alto rendimiento.
En general, cuando los estímulos de entrenamiento de fuerza y resistencia ocurren en paralelo, el estímulo de resistencia aumenta y las adaptaciones de fuerza se ven comprometidas, principalmente por una disminución del crecimiento muscular. Sin embargo, se puede aumentar el rendimiento de resistencia a través de adaptaciones no musculares (pulmones, corazón y sangre) y la fuerza se puede mejorar en cierta medida, sin la hipertrofia muscular.
Otros aspectos que son también importantes en el entrenamiento de fuerza y resistencia son la recuperación y la nutrición.
Concluye que buenos entrenamientos de fuerza y resistencia, son la mejor preparación, teniendo en cuenta el resto de las variables mencionadas.

Influence of upper body anaerobic pre-load exercise on energy metabolism and performance in an alpine ski-specific box-jump test. Sieder Mario et al.
Los sujetos realizaban un ejercicio de tren superior HIT, vieron el posterior efecto
metabólico en el esfuerzo principal que era la realización de un box jump. Se concluye que en esta carga previa no interfiere en el rendimiento del box jump pero aumenta el lactato antes del mismo, sin embargo el lactato neto al final de la prueba disminuye. La inducción de lactato por músculos no predominantes
puede aumentar el rendimiento en deportes de alta intensidad, aunque en
relación a la función neuromuscular.

Esquí alpino y salud cardio-metabólica. Dela Flemming et al.
El esquí no es el mejor ejercicio para aumentar V02max (indicador de capacidad funcional) pero un programa constante con duración determinada a largo plazo puede producir respuestas leves.

Microvascular oxygen extraction during competitive alpine skiing with regard to loaded and unloaded phases. Stöcker Fabian et al.
Examina el o2 microvascular extraído de la musculatura relevante durante competiciones, distinguiendo de la fase de carga y no carga. Recordar que en una carrera hay altas demandas aeróbicas y anaeróbicas, y todo lo que supone para su funcionamiento en relación al organismo. La muestra de este estudio fueron 6 esquiadores de élite de copa del mundo. Los valores de HB extraídos demuestran una extracción de 02 considerablemente alta durante una carrera. Incluso
esquiando con cargas muy altas, como en copa del mundo, el vasto lateral de la
pierna interior y exterior reduce la concentración de HB esquiando en un esfuerzo similar está asociado con una mejora de la extracción y el aporte de 02 micro vascular, el cual durante el giro ha está ligado a la velocidad de extracción de 02 durante las recuperaciones entre ejercicio. Esto se traduce en que los sujetos con mecanismos anaeróbicos veloces son más eficientes porque se reduce de esta manera la contribución anaeróbica, esto tiene gran aplicación en pruebas como el descenso.

PREVENCIÓN DE LESIONES Y SEGURIDAD

Changing the ski regulation to protect the athlete's knee: what was the justification? What do the data tell us? what did we learn? Kröll Josef et al.
Debido a las características del esquí alpino, el trabajo de fuerza y resistencia es inevitable. El primero para poder suplir las demandas de rendimiento del propio deporte y el segundo para poder aguantar numerosas y largas sesiones de entrenamiento. Hay que conocer las adaptaciones que se producen y su interferencia al ocurrir los estímulos de manera paralela. Este es el llamado entrenamiento concurrente. Estos cambios fisiológicos deben ser conocidos por los entrenadores y deportistas y
se debe intentar basar una planificación de acuerdo con los mismos, evitando las periodizaciones más tradicionales. Este artículo es interesante porque da orientaciones sobre como planificarlo diferentes deportes.

¿Son los esquís culpables del alto ratio de lesiones en esquí alpino? Supej Matej et al.
El esquí de élite tiene altos índices de lesión severa, a los que además se le suman pequeñas lesiones por sobre entrenamiento. Se están estudiando las diferentes propiedades de los esquís para ver como interaccionan con el medio y poder determinar la cadena de eventos que desarrolla una lesión, que

factores son intrínsecos y extrínsecos y la relación del índice de lesiones con la evolución del material a lo largo de los años y las condiciones de la pista. Algunas conclusiones son:

- Sorprendentemente y lejos de lo que pensábamos el cambio de material por la FIS en el 2013 ha reducido un 24% las lesiones de los deportistas (Haaland et al, 2016).
- Vibraciones vs radio (side-cut): se ha observado que las vibraciones se transmiten notablemente del esquí a la cabeza y esto deberíamos tenerlo en cuenta.
- Con una muestra de 8 equipos nacionales, se observó que en la adolescencia temprana las lesiones son comunes debido a vibraciones (derivadas en problemas de espalda) y al aumento del ángulo de canteo y uso de pivotaje.
- Se hacen aclaraciones con respecto a las fijaciones, concluyendo que queda mucho por avanzar en cuanto al desarrollo y la seguridad de las mismas.
- Además de por las características de los esquís, hay otros factores externos como las condiciones de la pista, la cantidad de personas esquiando al mismo tiempo, meteorología, etc. Que pueden influir en el aumento de lesiones.

En conclusión, las lesiones se dan por un desencadenamiento de factores, no uno solo.

¿Se pueden predecir dónde ocurren los accidentes en las competiciones de Copa del Mundo de esquí alpino? Gilgien Matthias et al.

El esquí alpino se considera una actividad de riesgo por su alto índice de lesiones sobretodo en DH (por la velocidad, la duración de la prueba y los saltos). Se quiere ver si en este tipo de pruebas los accidentes sufridos por chicos ocurren siempre en el mismo punto o en diferentes lugares, y buscar algún indicio que nos indique factores de riesgo. Se detallaban todas las variables que interferían en la prueba (trazado, pendiente, velocidad…) y se localizaban los puntos exactos donde hubo lesiones o accidentes. Se analizaban. Las lesiones o situaciones lesivas no se distribuyen en un patrón a lo largo del trazado de DH, suelen ocurren en lugares específicos. Este proceder puede ser un buen elemento que ayude a preservar la salud de los corredores y la seguridad en las pruebas.

Adapting a schoolbased injury prevention program to reduce injury risk in youth alpine racer: a pilot study. Doyle-Baker Patricia (Tish) et al.

Estudio realizado en Canadá con varios clubes de categorías inferiores. El estudio consistía en analizar como beneficiaba un programa de entrenamiento físico, bien planificado que incluyera varios días a la semana con prevención de lesiones incluso en pista (adaptaciones neuromusculares) con ejercicios de propiocepción/equilibrio/core. Se pasaban unos test iniciales, se seguían los entrenos y a pasado un tiempo se repetían. El desarrollo del mismo no fue muy fiable porque la muestra no fue elevada ni constante, pero si se obtuvieron resultados buenos. De aquí podemos extrapolar que es básico incluir prevención de lesiones en la preparación física.

Injuries and illnesses in elite youth alpine ski racers and the influence of biological maturity and relative age: a two-season prospective study. Müller Lisa et al.

Se trata de relacionar las lesiones de los jóvenes esquiadores con su estado madurativo según momento de nacimiento. A lo largo de dos temporadas se analizó una muestra de 82 corredores de un esquí estudio donde vieron que había un gran nº de lesiones sistemáticas. Se concluye que la maduración no interfiere demasiado, aunque es posible que los menos afectados sean los nacidos en el último cuarto del año. No hay diferencias entre género, y las lesiones más frecuentes tuvieron que ver con la rodilla- Una mínima prevención y Vargas adecuadas de trabajo pueden reducir mucho la probabilidad de que ocurra una lesión.

PSICOLOGÍA Y PEDAGOGÍA

Relationship of mental skills and cognitive performance parameters within alpine skiers, soccer players and martial artists. Amesberger Günter et al.

Analiza la capacidad de dar información de dos tipos de test aplicados en deportistas adolescentes. Usa la batería de test QMSAS, 2008- habilidades mentales y actitudes en el deporte. Resultados: los esquiadores tienen menor capacidad de concentración que los futbolistas, y su esperanza de éxito pre-competición es relativamente más baja que en las artes marciales. De aquí concluyen que estos dos tests, son fiables y válidos para obtener la información requeridas, y diferencia factores cognitivos y mentales en diferentes deportes. Esto puede servir de orientación del entrenamiento.

Inhibition and working memory of alpine skiers, soccer players and martial artists. Finkenzeller Thomas et al. Analiza factores cognitivos en relación al rendimiento y memoria en adolescentes de diferentes deportes. Esto se mide a través de un test que realizan los deportistas: Eriksen flanker (EF) task (Eriksen & Eriksen, 1974). Determina ciertos patrones de actuación y agrupa resultados. Compara esquiadores con deportistas de artes marciales: nuestra capacidad de reacción (esquiadores) ante un estímulo incongruente es menor que en las Artes marciales. Respecto a la comparación de la memoria no hay resultados concluyentes. Estos test proporcionan información válida y objetiva, y permiten comparar capacidades interdeportes.
The flow experience in alpine skiing. Brandauer Thomas et al. **Flow and performance during race-like alpine giant slalom skiing.** Bernatzky Patrick et al. Existe una relación entre el flow y el máximo rendimiento. El flow produce una sensación de bienestar y disfrute de la práctica, es muy característico de los deportes de deslizamiento, aunque esto no está claro en los ámbitos fuera de lo recreativo. En este estudio se ha visto que, para las pruebas de esquí, GS y SL existe esta relación, pero depende de varios factores: la condición de la pista, el haber cometido errores serios previos y la propia intensidad experimentada. Hay altas correlaciones entre el tiempo de la carrera (y el puesto) y el nivel de flow. Si percibo y siento que esquío bien y a gusto, obtengo mejores resultados. En un entreno el flow se suele reducir a lo largo de las bajadas (deterioro de la pista).
Visual inspection of skiing course and terrain using virtual and augmented environment. Khlamov Maxim et al. Los avances tecnológicos han permitido que se puedan desarrollar programas que permitan ver el movimiento en 3D. Se usaron móviles y drones para sacar el movimiento previamente de un esquiador. Se ven incluso los grados de inclinación de la pista y el propio relieve. Se consideran problemáticas típicas de la percepción visual. Esta técnica es útil en situaciones difíciles, para aumentar la seguridad en carrera si hay poca visibilidad, o malas condiciones climatológicas.
ASPECTOS TÉCNICOS Y BIOMECÁNICOS
The point of force application during the turn and its meaning for science in skiing. Senner Veit et al. Es importante determinar el punto de aplicación de fuerza (usando una tecnología precisa y adecuada) para comprender mejor los conceptos de la física y aplicarlos a la técnica de manera lógica. Se analizan patrones de movimiento de giro corto, derrapado, conducido, en cuña, paso patinador y descenso directo. Con estos datos se pueden realizar muchos avances futuros en el desarrollo de la técnica.
Ski turn kinematics: a comparison between downhill skiing and training on skiing simulators. Woznica Wojciech et al. Cada vez se están construyendo más simuladores con diferentes características para el entreno. No todos tienen transferencia real con el esquí. Se analizaron varios: Revolving slope, SkyTechSport Ski Simulator ProSkiSimulator Skier's Edge. Se concluye que el rango de movimiento de los planos frontales y sagitales de las articulaciones bajas y la proyección de la fuerza centrípeta en el cuerpo era mucho mayor en esquí real. Los parámetros más cercanos seleccionados al esquí eran los que se registraron con el Skytechsport. El porskisimulator y el skier's edge tenían limitaciones para recrear los parámetros del esquí, sobre todo por ser ejercicios de cadena cinemática cerrada.
Comparative electromyography analysis of skiing on slope and in simulating conditions. Szymanska Dominika A. et al. La EMG es el método más fiable y preciso para determinar el patrón de intervención muscular. Se usa en el Skytech, analiza a 5 sujetos, profesores de esquí y se concluye que el nivel de activación muscular es bastante individualizado pero hay una característica notable cuando realizas variantes de un ejercicio en diferentes condiciones. Se elige el skytech porque con otros elementos no se alcanzaban altas amplitudes en los valores de EMG.
Predictors of instantaneous performance in alpine giant slalom – how to best solve the permanent trade-off between shortening the path while maintaining speed? Spörri Jörg et al. La tendencia en el alto rendimiento: Rendir en todas las secciones de la carrera para conseguir el max resultado (alta v) o aprovechar una sección para alcanzarlo (acortar línea). Este análisis se hace en función de la energía disipada/velocidad o a acortar la línea del esquiador. Esto puede ser interesante para los visionados de video y a los entrenadores de cara a estrategias.

Alpine ski racing gate crossing detection using magnetometers. Fasel Benedikt et al. Buscando una mayor precision e interpretación en los análisis de video de los deportistas, se idea un sistema que mide el tiempo entre puertas (usa un magnemómetro en las puertas y el deportista lleva un dispositivo que detecta un campo magnético). Aún tienen ciertas limitaciones prácticas.
Variations of the relative age effect within and across groups in elite alpine skiing. Bjerke Øyvind et al. Plantean la hipótesis de que existe un efecto relativo de la edad en el rendimiento según el momento del año en que hayas nacido. Esto es así en las categorías anteriores a la élite, por lo tanto, queremos analizar que pasa en WC. La mayoría de los deportistas, generalizando pertenecen al primer cuarto de año. Los resultados concluyen que, dividiendo en dos tipos de disciplinas, técnicas y de velocidad, en las de velocidad es importante haber nacido en los primeros cuartos del año por la constitución física. Sin embargos los datos nos muestran que los hombres líderes de copa del mundo son los nacidos en los dos últimos cuartos, explicado por la motivación.
MATERIAL
Ski bindings, inadvertent release, and ACL injuries. Brown Christopher A. et al. Cada vez se da más importancia al desarrollo de las fijaciones como mecanismo para evitar lesiones de ACL, Estas filtran las cargas lesivas a la tibia si se ajustan de manera extrema. Para proteger el ACL, las fijaciones deben responder correctamente ante el valgo y la rotación interna de rodilla que se pueda producir. Que actúen de manera rápida a los golpes y a las flexiones del esquí. Las fijaciones actuales necesitan reinventarse, no solo tener movilidad lateral en la puntera sino también vertical de puntera a talón. Y esto puede ser una buena solución en el alto rendimiento. Aún faltas estudios experimentales futuros que mejoren estos mecanismos.
Does ski width influence muscle activity and ski actions in an elite skier? A case study. Seifert John et al. Verdaderamente la actividad muscular puede ser muy influida por la técnica, características antropométricas, etc. Esquiar con esquís anchos, cambia sustancialmente los movimientos, el patrón muscular comparado con un esquí de SL. Con esquís anchos se consigue un ángulo de extensión mayor que con esquís de SL. Los datos nos revelan que se producen pequeñas modificaciones en la técnica como en la actividad muscular.
Ski binding loads generated during alpine skiing and alpine touring skiing: a comparison of the retention requirements. Campbell Jeffrey et al. Se coge una muestra reducida de esquiadores alpinos y esquiadores de travesía. Se les pone una plataforma de fuerza en las botas y les hacemos bajar por la misma pista. Analizamos diferencias en las fuerzas que suceden en la fijación. Encuentran diferencias en el análisis de ambas fijaciones y su comportamiento en la bajada. La retención-liberación prescrita por estándares internacionales es suficiente para dar un mínimo de retención en los test de esquiadores y esq. De travesía.

4. PROGRAMA SOCIAL

El programa social estaba formado por diferentes actividades grupales en las que podían participar todos los asistentes, ponentes y acompañantes. Estaban planificadas entre el programa científico. Y se distribuyeron en el programa de la siguiente forma:

- Sábado 10 de diciembre:
  - De 17 a 19h: Ceremonia de Apertura. En la que estaba incluida una exposición oral (Opening Keynote) de una hora de duración.
  - De 19 a 23h: Recepción y registro de los participantes. Entrega de documentación y programa del congreso.
- Domingo 11 de diciembre:
  - De 13 a 16:30h: Esquí guiado en el área de Arlberg. Hicieron diferentes grupos por niveles de esquí y nos asignaron un guía que nos hizo un tour por la estación.
  - De 20:15 a 23h: Advent Evening: Concierto de pre navidad de arpa y acordeón en Arlberg 1800. Cóctel después del concierto en la recepción del hotel.
- Lunes 12 de diciembre: Dos actividades a elegir una:
  - Paseo de 50 minutos con raquetas y antorchas.
  - Ski Touring. Recorrido de 60 minutos desde el hotel hasta Galzing.
- Martes 13 de diciembre:
  - De 13 a 16:30h: Esquí guiado en el área de Arlberg. Con el mismo grupo del día anterior.
  - De 16:15h a 18:30h: Fiesta de après ski en St. Anton a Arlberg.
  - De 20:15 a 21h: Conferencia especial de Stefan Häusi, uno de los mejores freerider del mundo.
- Ceremonia de Clausura:
  - De 20:15 a 21h: Ceremonia de clausura en la cual entregaron el premio al joven investigador.
  - De 21:00 a 24h: Cóctel de despedida.

5. PARTICIPACIÓN DE LA MUJER EN EL CONGRESO:

5.1 Participación de la mujer en el comité científico y en la organización del congreso:

Comité Científico:
De los 22 miembros del Comité Científico 19 son hombres y 3 mujeres. Una cifra poco representativa para la mujer y poco equitativa.
De entre los 22 miembros del Comité Científico, hay 5 miembros principales compuesto por 1 presidente y 4 vicepresidentes, entre los que no hay ninguna mujer.

Comité de Organización:
El Comité de organización, está compuesto por profesores y profesoras de la Universidad de Salzburgo. En total son 17 miembros de los cuales 13 son hombres y 4 mujeres. Una de ellas ocupa el cargo de Secretaria del Congreso.

De estas cifras podemos observar la poca participación de las mujeres en estos Comités, siendo de un 13.5% en el Comité Científico y de aproximadamente un 23.5% en el Comité de Organización. Los cargos que ocupan no son de responsabilidad en ninguno de los dos Comités. De los 5 cargos entre presidencia y vicepresidencia, ninguno lo ocupa una mujer.

En conclusión, se debería de incrementar la presencia de la mujer en dichos Comités. Siendo necesarios programas de ayuda e impulso a la participación de la mujer, como el programa Mujer y Deporte, del Consejo Superior de Deportes.

5.2 Participación de la mujer en las exposiciones orales y posters:

Las 4 keynote sessions, con una duración superior al resto de presentaciones, fueron realizadas por hombres.

De las 93 presentaciones orales, 10 fueron realizadas por mujeres y 83 fueron realizadas por hombres.

De los 44 Póster presentados, 6 fueron realizados por mujeres y 38 por hombres.

La participación de la mujer, por lo tanto, en las presentaciones es de un 0% en las Keynote sessions, un 10.8% en las presentaciones orales y un 13.7% en las presentaciones en formato Póster. Unas cifras muy modestas de participación de las mujeres en este 7º Congreso de Ciencia y Esquí.

Estos datos nos muestran la necesidad del impulso de la participación mujer técnico investigadora en este congreso.

Gracias a las becas del Programa Mujer y Deporte del CSD y de la Real Federación Española de Deportes de Invierno, realicé una presentación en formato de póster,

titulado “Empatía y Regulación Emocional del entrenador de esquí alpino y su influencia sobre los resultados de sus deportistas.”

6. PRESENTACIÓN EN POSTER: Empatía y Regulación Emocional del entrenador de esquí alpino. Impacto en los resultados de sus deportistas:

Las presentaciones de los póster fueron el lunes 12 de diciembre de 17:45 a 18:45, en tres lugares distintos. Para cada bloque de presentación de póster, había dos directores pertenecientes al comité científico. Las presentaciones se hicieron una a una según el horario establecido, pasando de una a otra cada 5 minutos aproximadamente.

La presentación de mi póster fue a las 18:15h en el hall de la recepción. Stefan Lindinger y Thomas Stöggl, pertenecientes al Comité Científico, fueron los directores de esta sesión. La presentación duró 5 minutos de los cuales en 2 minutos se hacía la exposición oral y en los siguientes 3 min se hicieron las preguntas a cargo de los directores de la sesión, 2 preguntas en total:

- Si solo se había estudiado el perfil del entrenador y no del deportista. La respuesta fue que en este caso el interés del estudio es el entrenador, medir su perfil de empatía y de regulación emocional.
- Si actualmente se realiza alguna formación al entrenador en lo que respecta al desarrollo de la empatía y de la regulación emocional. La respuesta fue que actualmente no.

ABSTRACT:

EMPATHY AND EMOTIONAL REGULATION OF ALPINE SKI AND SNOWBOARD COACHES AND THE IMPACT ON THE PERFORMANCE OF THE ATHLETES.

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Keywords: empathy; emotional regulation; performance; emotional skills; alpine ski coach; snowboard coach.

INTRODUCTION: There has been little research on the non-technical skills and abilities of winter sports coaches. Emotional and empathic skills have been very relevant in both education and performance. Empathy has been identified as one of the essential qualities required by a sport coach with knowledge and motivation (Martens, Christina, Harvey and Sharkey, 1989). The domain of emotional competencies favors the learning process, interpersonal relationships and problem solving (Bisquerra & Pérez, 2007). The aim of this study is to identify the impact that skills such as emotional regulation and

empathy of alpine skiing and snowboarding coaches has on the performance of their athletes.

METHODS: The sample for the study was a heterogeneous and representative sample of women and men Alpine Ski and Snowboard Spanish coaches, between 18 and 60 years old. The instruments used were: 1.) Test of Cognitive and Affective Empathy (TECA, Lopez-Perez, Fernandez-Pinto and Abad, 2008) to measure empathy. It consists of 33 elements that provide information on both cognitive components and affective components. 2.) Difficulties in Emotion Regulation Scale (DERS, Gratz & Roemer, 2004) to measure emotional regulation. This scale assesses different features of the emotion regulation process that may have several difficulties associated, including emotional lack of control, lack of emotional attention, life interference, emotional confusion, and emotional rejection. The dependent variable considered was the performance of athletes measured by the results of the last season through the RFEDI points of each athlete. The independent variables of our study were empathy and emotional regulation of coaches. Data analysis was performed by a multiple linear regression analysis using the method "stepwise". This multiple regression model was used to identify the strength of the effect that the independent variables (empathy and emotional regulation of coaches) have on the dependent variable (performance of athletes). It was also used to predict the effects or impacts of changes.

RESULTS: Actually, the data collection is ongoing. Therefore, first results will be presented on the poster, and cannot be presented here.

DISCUSSION: Regression analysis allows measuring the impact of the empathy and emotional regulation skills of coaches on the performance of their athletes. Furthermore, predicting the performance of other athletes based on empathy and emotional regulation of their coaches, will be discussed based on the new data set.

CONCLUSION: Identifying the impact of empathy and emotional regulation of Alpine Skiing and Snowboarding coaches on the performance of their athletes will potentially allow us to approach the ideal profile of the coach in order to predict the success of their athletes according to their skills.

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Sharkey, B. J. (1989). El entrenador. Nociones sobre psicología, pedagogía, fisiología y medicina para conocer el éxito. Barcelona: Hispano-Europea.

PÓSTER:

EMPATHY AND EMOTIONAL REGULATION OF ALPINE SKI COACHES AND THE IMPACT ON THE PERFORMANCE OF THEIR ATHLETES.

Marta Pintado Riesco, Miguel Ángel Pérez Nieto — *School of Health. Universidad Camilo José Cela*

INTRODUCTION

There has been little research on the non-technical skills and abilities of winter sports coaches. Emotional and empathic skills have been very relevant in both education and performance.
Empathy has been identified as one of the essential qualities required by a sport coach with knowledge and motivation (Martens, Christina, Harvey and Sharkey, 1989).
The domain of emotional competencies favors the learning process, interpersonal relationships and problem solving (Bisquerra & Pérez, 2007).

OBJECTIVES

1. Describe the profile of the empathy and emotional regulation skills of the alpine skiing Spanish coaches.

2. Identify the impact that skills such as emotional regulation and empathy of Spanish coaches for alpine skiing teams have on the performance of their athletes.

METHODS

SAMPLE:
The sample for the study was a heterogeneous and representative sample of 55 women and men alpine skiing Spanish coaches, between 18 and 60 years of age.
INSTRUMENTS :
1.Test of Cognitive and Affective Empathy (TECA, Lopez-Perez, Fernandez-Pinto and Abad, 2008) to measure empathy. It consists of 33 elements that provide information on both cognitive components and affective components.
2.Difficulties in Emotion Regulation Scale (DERS, Gratz & Roemer, 2004) to measure emotional regulation. This scale assesses different features of the emotion regulation process that may have several difficulties associated, including emotional lack of control, lack of emotional attention, life interference, emotional confusion, and emotional rejection.

STUDY DESIGN

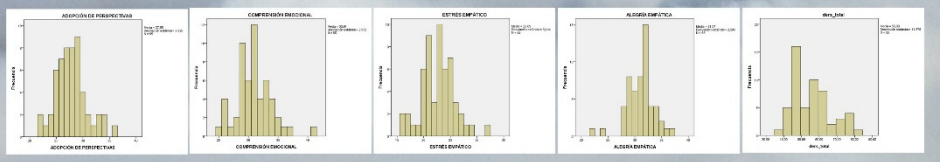
Dependent variable: The performance of athletes measured by the results of the last season according to their position in the RFEDI ranking.

Independent variables: The empathy and emotional regulation of coaches.

DATA ANALYSIS AND RESULTS

The data analysis was performed using the statistical program SPSS 24.0.

Objective 1: Frequency analysis and histograms.



Objective 2: Data analysis was performed first using a bivariate correlation analysis to measure the relationship between the variables.

Correlaciones

		ADOPCIÓN DE PERSPECTIVAS	COMPRENSIÓN EMOCIONAL	ESTRÉS EMPÁTICO	ALEGRÍA EMPÁTICA	DESATENCIÓN	CONFUSIÓN	RECHAZO	INTERFERENCIA	DESCONTROL	DERS
RESULTADO DAMAS	Correlación de Pearson	-0,104	0,054	-0,154	-0,113	-0,097	-0,113	-0,074	-0,117	-0,090	-0,149
	Sig. (bilateral)	0,487	0,716	0,300	0,451	0,516	0,451	0,620	0,432	0,548	0,318
	N	47	47	47	47	47	47	47	47	47	47
RESULTADO HOBRES	Correlación de Pearson	0,115	0,021	0,176	0,043	-0,065	-0,007	0,015	-0,089	-0,058	-0,054
	Sig. (bilateral)	0,415	0,881	0,211	0,761	0,647	0,962	0,915	0,528	0,685	0,702
	N	52	52	52	52	52	52	52	52	52	52

*p < .005 **p < .001

As a result of not obtaining any significant correlation between the variables, the independent samples T- test was done from two extreme groups: Group 0 = Coaches with athletes from the best 15 results. Group 1 = Coaches with athletes placing from 70th to last place. When there were no significant differences between both groups, a 1-factor ANOVA was done, which also obtained no significant differences.
A multiple regression analysis was not performed because there was no significant correlation between the variables.

CONCLUSION AND DISCUSSION

Objective 1: The mean score of alpine skiing Spanish coaches showed an average score for empathy on both cognitive and affective components. The average score for Difficulties in Emotion Regulation Scale was 55.8 out of 140. So alpine skiing Spanish coaches don´t encounter difficulties when using emotional regulation strategies.

Objective 2: Emotional regulation and empathy skills of alpine skiing Spanish coaches don´t have any impact on the performance of their athletes, as there are no significant differences between the variables. As such, performance cannot be predicted.

REFERENCE LIST: Bisquerra, R. & Pérez, N (2007). Las competencias emocionales. Educación XXI, 10, 61-82. García Llamas, J. L.; González Galán, M. A. y Ballesteros Velázquez, B. (2001). Introducción a la investigación en Educación. Unidades Didácticas. Madrid, UNED. Gratz, K. L., & Roemer, L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. Journal of Psychopathology & Behavioral Assessment, 26(1), 41-54. Hervás, G. y Jódar, R. (2008). Adaptación de la Escala de Dificultades en la Regulación Emocional. Clínica y Salud, 19, 139-156. López-Pérez, B., Fernández-Pinto, I. y Abad, F. J. (2008) TECA. Test de Empatía Cognitiva y Afectiva. Madrid: Tea Ediciones, S.A Lorimer, R. (2013). The development of empathic accuracy in sports coaches. Journal of Sport Psychology in Action. Martens, R. (2002). El entrenador de éxito. Barcelona: Paidotribo. Martens, R., Christina, R. W. Harvey, J. S. & Sharkey, B. J. (1989). El entrenador. Nociones sobre psicología, pedagogía, fisiología y medicina para conocer el éxito. Barcelona: Hispano-Europea.

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7. CONCLUSIONES DEL CONGRESO ICSS 2016

Gracias a este Congreso de Ciencia y Esquí, se impulsa la investigación en los deportes de invierno y se dan a conocer las conclusiones de diferentes estudios llevados a cabo en otros países. Además de abrir nuevas posibles líneas de investigación, permite y facilita la actualización de técnicos y profesionales de los deportes de invierno.

La mujer actualmente tiene poca representación en este Congreso, por lo que programas como el de Mujer y Deporte del Consejo Superior de Deportes y la Real Federación Española de Deportes de Invierno, son necesarios para impulsar el incremento de participación tanto a nivel de investigación como a nivel de participación de carácter solamente formativo.

En esta edición, gracias a este programa de becas, hubo representación de mujeres españolas: 5 mujeres de interés formativo y 1 mujer de interés formativo y de investigación.

Poca representación de España en las presentaciones. Solo hubo una presentación oral realizada por el Dr. José Sancho, profesor de la Universidad Pública de Navarra, sobre la construcción de los esquís Boreas. Y una presentación en Póster mencionada expuesta en el punto 6.

En cuanto al programa científico en líneas generales, resaltar, pocos estudios sobre técnica de esquí alpino, de psicología y de pedagogía. Numerosos sobre fisiología y entrenamiento enfocados a la mejora del rendimiento para todas las disciplinas. Gran mayoría de investigaciones de técnica de esquí de fondo.

ANEXO

ABSTRACTS:

Concentric, isometric, and eccentric contractions: which dominates alpine skiing?

Minetti Alberto

Despite a slowly growing body of literature, uncertainty persists about which are the predominant muscle actions in Alpine Skiing. This is certainly due, among all, to technical difficulties in sampling and analysing the relationship between the different physio-mechanical variables involved (EMG, forces, kinematics) and kinetic aspects of the body centre of mass (altitude, trajectory, speed, speed changes, mechanical energies) during the descent. A deeper understanding of the role of muscles in downhill skiing would help to better define pre-race training sessions, and also to design specific training machines for athletes. Despite of the inspective observation of joints flexions and extensions, can we expect a stronger contribution from concentric, isometric or eccentric muscle contractions? Alpine skiing deals just with descending mountains, therefore the potential energy (= mass.gravity.Δaltitude) achieved by the body during ascending (by using cable cars, for instance) has to vanish when returning at the bottom of the track. Such an energy dissipation (or negative work) is inevitable, and seems to suggest that eccentric contractions will dominate the skiing action overall. A passive hardware model by Helmut Gottschlich and Hans Zehetmayer (1978) challenges that concept. Although it is intuitive to conceive that just snow friction could do the (negative) work when a fixed posture is assumed, as in 'Stem-Christiania' or 'Snowplough' style (which would imply that muscle action could be just isometric), their model shows that the lowest (extra) energy needed to perform a slalom is zero. The skier posture of their passive model suggests that joints' angles can be kept almost constant, which translates into isometric muscle actions in the 'biological' model. Finally, during descent overall body energy is expected to continuously decrease because of snow friction, which impairs the transformation of potential into kinetic energy of the body centre of mass. It is theoretically plausible, though, that in some instances (at the end of a turn) the skier's speed increases more than the decrease in the net available mechanical energy (potential energy - work against snow/air friction). This extra-positive work could be provided by some concentric muscle-tendon unit contraction occurring after having been forcefully lengthened in the centrifugal phase (eccentric activation + tendon stretch) of the turn. This occurrence, sometimes visible in a sort of slight skating push, could be responsible, via power-amplification, of some 'active' speed gain of the athlete. So, as seen above, we face a motion activity where overall (extra) energy needed could be zero (no muscle action required), or where muscle force could be predominantly eccentric, isometric or even concentric. The only chance to reveal the intimate physio-mechanical nature of downhill skiing is to design field experiments where multi instrumented (EMG, electro goniometers, high speed GPS with barometric correction, inertial sensors) skiers are measured along accurately measured (GIS corrected GPS 3D trajectory, high spatial/temporal resolution video capture) tracks, where most of the mechanical energy exchange/dissipation/generation should be estimated.

Are the skis to blame for high injury rates in alpine skiing?

Supej Matej

INTRODUCTION: Alpine skiing is a popular outdoor winter sport with approximately 400 million skier visits worldwide (Vanat, 2016). It is known that recreational alpine skiing is associated with high injury rates ranging from 2.4 to 7.0 injuries per 1,000 activity days (Hebert-Losier & Holmberg, 2013). In competitive skiing these injury rates are several times higher (Haaland, Steenstrup, Bere, Bahr, & Nordsletten, 2016). In addition to frequent acute injuries, overuse injuries are also common (Hildebrandt & Raschner, 2013). It is therefore no surprise that alpine skiing was stated to be "the riskiest sport undertaken by adults on a routine basis" (Hunter, 1999). DISCUSSION: Skis can be described by several properties such as ski length, ski width, side-cut radius, camber profile, weight, inertial properties, bending and torsional stiffness, ski edges and running base. In addition, ski plates and bindings with their properties are often considered to belong to skis, especially with a trend of integrating three part together. Note that skis, ski plates and ski binding and to some extend ski boots may interfere with each other and alter overall "skis" properties. In this presentation the above-mentioned "skis" properties will be discussed in connection with potential traumatic and overuse injury risk in alpine skiing on different levels and different skiing conditions. Mostly biomechanical parameters and methodology will be used to better describe skiing and injury risk. CONCLUSION: In order to better answer the title's question, the skis' properties and their connection to injury risk will be further elucidated with: 1) chain of events that is needed to lead to an injury, 2) which risk factors are intrinsic to alpine skiing and which factors are extrinsic (e.g. last-run of the day or after-lunch skiing) and 3) a connection of injury rates to changes in e.g. safety equipment, skiing traffic and slope preparation over the years. REFERENCES: Haaland, B., Steenstrup, S. E., Bere, T., Bahr, R., & Nordsletten, L. (2016). 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, 50(1), 32-36. doi: 10.1136/bjsports-2015-095467 Hebert-Losier, K., & Holmberg, H. C. (2013). What are the exercise-based injury prevention recommendations for recreational alpine skiing and snowboarding? A systematic review. Sports Med, 43(5), 355-366. doi: 10.1007/s40279-013-0032-2 Hildebrandt, C., & Raschner, C. (2013). Traumatic and overuse injuries among elite adolescent alpine skiers: A two-year retrospective analysis. Int Sport Med J, 14(4), 245-255. Hunter, R. E. (1999). Skiing injuries. Am J Sports Med, 27(3), 381-389. Vanat, L. 2016 International Report on Snow & Mountain Tourism - Overview of the key industry figures for ski resorts 8th edition - April 2016. Retrieved [Accessed: 12.7.2016, from http://www.vanat.ch/RM-world-report-2016-vanat.pdf]

Moderate Load Eccentric Exercise

Hoppeler Hans

In recent years a number of studies have been published using progressive eccentric exercise protocols on motorized ergometers. These devices allow for controlled application of eccentric loads. Training loads reach 400–500 W in typical rehabilitative settings and over 1200 W in elite athletes. Training is generally carried out three times per week for durations of 20–30 min. We

have named this type of training “moderate load eccentric exercise”. Moderate load eccentric exercise is distinct from plyometric exercises (i.e., drop jumps) that impose muscle loads of several thousand Watts. It is also distinct from eccentric overload training whereby loads in a conventional strength training setting are increased in the eccentric phase of the movement to match concentric loads. Moderate load eccentric exercise has been shown to be similarly effective as conventional strength training in increasing muscle strength and muscle volume. However, as carried out at higher angular velocities of joint movement, it reduces joint loads. A hallmark of moderate load eccentric exercise is the fact that the energy requirements are typically 4-fold smaller than in concentric exercise of the same load. The use and effectiveness of moderate load eccentric exercise has been demonstrated mostly in small scale studies for cardiorespiratory conditions, sarcopenia of old age, cancer, diabetes type 2, and neurological conditions. It has also been used effectively in the prevention and rehabilitation of injuries of the locomotor system in particular the rehabilitation after anterior cruciate ligament surgery.

The Challenge of Training for Strength and Endurance

Gross Micah

Performance in most sports is benefited by good muscle strength and power, and these characteristics also help maintain training quality and reduce the risk of injury in spite of fatigue, especially in non-cyclic sports. Also, some level of endurance (aerobic conditioning) is required in almost all sports, be it for achieving top performance or mainly for coping with large training loads. Especially in complex sports, for example skiing and snowboarding, some combat sports, and most game sports, managing one’s time to effectively develop various qualities, such as strength and endurance—not to mention others, such as coordination and technical skill—in a sport-specific or individually optimal manner becomes challenging. Making the challenge even greater is the reluctance of skeletal muscle to simultaneously adapt structurally and metabolically to competing strength and endurance training stimuli, respectively. In general, when strength and endurance training stimuli occur in parallel, the endurance stimulus comes out on top and strength adaptations are compromised, mostly via diminished muscle growth. However, some endurance performance gains can be made via non-muscular adaptations (lungs, heart, and blood) and strength can be enhanced to some extent without muscle hypertrophy. Insights from numerous training studies and biomolecular investigations can be applied when designing training plans, from the most reasonable weighting of the various strength (high-intensity or high-volume) and endurance (continuous or interval) training forms and their periodization in the annual cycle, to the spacing and order of divergent stimuli in weekly or daily cycles. Further aspects that become more important in the challenging situation of training for strength and endurance are recovery and nutrition.

Comparison between cross-country skiing on snow and roller skiing on treadmill with the same track profile

Ruostekoski Anni , Ohtonen Olli , Ruotsalainen Keijo , Kainulainen Heikki , Linnamo Vesa

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Introduction: Roller skiing is a popular training modality among cross- country (XC) skiers during summer and it is also widely used in laboratory testing as well as in basic training on treadmill. By using special designed virtual environments combined with treadmill it is also possible to get familiar with competition tracks of important races. The purpose of this study was to examine if skiing on snow and roller skiing on treadmill following the same track profile would lead to similar physiological responses. Methods: Nine young (17-22 years) high level male skiers performed two XC skating sprint training sessions, one on snow and one roller skiing on a treadmill. Each session consisted of three 1.2 km intervals (LOW, HIGH and MAX) corresponding approximately 70%, 85% and 100% of maximal heart rate. In the treadmill session, the snow track was mimicked by adjusting the treadmill to follow the altitude changes of the real track and the real environment was mimicked by a virtual environment. The speed of the treadmill was adjusted individually for each subject on the basis of their performance in the snow session. Rest between the intervals was 3 min. Heart rate was monitored throughout all the sessions. Blood lactate samples were collected before the first and immediately after every interval as well as 6 and 10 min after the last interval. Results: Mean times for LOW, HIGH and MAX were 4.02 min ±14 s, 3.49 min ± 9 s and 3.41 min ± 7 s, respectively. A significant difference in blood lactate concentration was found after the MAX interval lactate being 13.4 ± 1.7 mmol/l on snow vs. 8.8 ± 3.7 mmol/l on treadmill right after the interval ($p < 0.01$). The lactate values were higher on snow also after 6 min (13.3 ± 1.6 mmol/l vs. 7.8 ± 3.8 mmol/l, $p < 0.01$) and after 10 min (12.6 ± 2.4 mmol/l vs. 6.6 ± 3.5 mmol/l, $p < 0.01$) in MAX. Also the mean heart rate was higher on snow in MAX (181 ± 8 bpm vs. 172 ± 10 bpm, $p < 0.05$). No other significant differences were found either in heart rate or lactate between the different sessions. Discussion/Conclusion: The difference in lactate concentration and heart rate after MAX despite the similar speeds indicates a bigger load for muscles leading to either higher lactate accumulation or production when skiing on snow compared with roller skiing on treadmill. In the present study, the slow snow conditions and the passive downhills on the treadmill might have contributed to the results at some level. However, the possible difference in muscle load might be a point to take into account when planning or monitoring training sessions based on the heart rate or speed either on snow or treadmill. In conclusion, in the present study skiing and roller skiing performances were quite similar to each other from the physiologic perspective on submaximal levels but differences in the physiologic response due to higher muscle load in maximal effort sessions can exist.

Analysis of sub-techniques in classical cross-country skiing by employing machine learning algorithms on micro-sensor data

Rindal Ole Marius Hoel, Seeberg Trine M., Tjønnås Johannes, Haugnes Pål , Dalgard Steffen , Sandbakk Øyvind

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INTRODUCTION: In classical cross-country skiing, diagonal stride (DIA), double poling with a kick (DK) and double poling (DP) are the main sub-techniques employed in the varying terrain. These are all used with the skis in parallel following a track. The skier continuously changes between sub-techniques while striving to use the most efficient one at each part of the course. However, the distribution of these sub-techniques are not logged in skiers' daily training and competitions, even though such information would provide a unique insight on technical and tactical aspects. In this study, we examined the feasibility of utilizing a machine learning algorithm on micro-sensor data to automatically classify the main sub-techniques in classical cross-country skiing.

METHODS: A micro-sensor system, IsenseU-Ski, that synchronizes and records data from seven inertial measurement units (IMUs) placed on the body of the skier, in combination with recordings of GPS data and heart rate, has been developed. By using this system, we recorded 11 different skiers (ten men and one woman, age: 30±8 years, body height: 180±6 cm, body mass: 73.0±8.4 kg), both while roller skiing on a treadmill and while skiing outdoors on snow. The subjects were both amateur skiers and professional world cup skiers. The field tests were performed both in flat recreational skiing tracks and in competitive tracks with hilly terrain and sharp turns. We trained a machine learning algorithm using a neural network on data from four of the subjects in order to automatically recognize and classify each cycle to one of the main sub-techniques; DIA, DP, DK or a fourth class covering miscellaneous movement. The employed algorithm only need sensor data from two of the sensors to detect the sub-techniques; one on the chest to log the torso movements, combined with one on the arm to assure a robust cycle detection. The sensor data was synchronized with video recordings of the skiers to manually validate the classification of the sub-techniques. RESULTS AND DISCUSSION: The average accuracy of classifying sub-techniques was 92% when using this machine learning method. The sensitivity for the three main sub-techniques was high, and the misclassified cycles were mainly related to the miscellaneous class; such as cycles that included transition between two sub-techniques or cycles performed in a sharp turn. The results are displayed as detailed GPS tracks with the coinciding sub-techniques used at a given position, in addition to the total distribution of each sub-technique during the session. Since the IMU-data from all seven sensors were synchronized with GPS-based speed, inclination data and heart rate, the used sensor system also allows detailed analyses of the various sub-techniques and other cyclic parameters in cross-county skiing.

Classification of Ski Skating Techniques using the Head's Trajectory for use in GNSS Field Applications

Gløersen Øyvind, Gilgien Matthias

INTRODUCTION: Cycle length (CL), cycle duration (CD) and choice of sub-technique are all important determinants of skiing performance (Andersson et al. 2010; Losnegard et al. 2012). A system capable of automatically detecting these three parameters in field conditions would therefore be useful. Fasel et al. (2015) presented an IMU-based solution for the diagonal stride technique, however, the lack of a kick phase impedes this approach to ski skating. Similar approaches in the skating techniques have been limited to constant velocity situations (Myklebust et al. 2015). A possible solution to overcome these limitations and at the same time compute instantaneous performance measures (Gilgien et al. 2016) is to use differential Global Navigation Satellite Systems (dGNSS). Suitable dGNSS provide a trajectory of a landmark on the skier at 50 Hz and accuracy <5 cm (Gilgien et al. 2014). The aim of this study was to evaluate dGNSSs to extract cycle characteristics, and to classify the sub-technique used during ski skating. METHOD: 5 elite male cross-country skiers performed 6 submaximal loads on a roller ski treadmill using different sub techniques (V1, V2 and V2a). The trajectories of 41 reflective markers were distributed on their skin and equipment, and were recorded using an optical motion capture system sampling at 250 Hz. The trajectory of a marker on the head was downsampled to 50 Hz, and was considered to represent a trajectory from a dGNSS antenna. The start/end point of each technique cycle was determined from the maximal sideways velocity

(from left to right), and was used to calculate CD. CL was calculated from the forward displacement of the head marker in a reference frame moving with the treadmill band. Finally, a neural network classifier was trained to separate the three skating techniques used (V1, V2 and V2a). The input to the neural network was a 6-dimensional vector characterizing the technique cycle. Specifically, it contained the CD, CL, sum of head displacement in the vertical and sideways directions, and two parameters describing the symmetry of the technique cycle. The estimates of CD and CL were validated using time points of pole plants (maximal acceleration of pole marker) and the forward displacement of the center of mass of the athletes (using the model by (Myklebust et al. 2015)). The classification algorithm was trained on a subset of the data consisting of 1, 2 or 3 athletes, and then tested on the remaining athletes when skiing on different conditions (inclination or velocity) than used during training. RESULTS: The systematic error in CD was between 3-9 ms when averaged over 10 cycles, and between 50-80 ms over a single cycle. The error in the CL estimates was 1.4-2.5 cm averaged over 10 cycles, and 16-37 cm for a single cycle. The errors were largest for the V2a technique, and smallest for the V1 technique. The classification algorithm correctly classified 98.3%, 99.3% and 100% of the cycles when being trained on 1, 2 or 3 athletes respectively. DISCUSSION AND CONCLUSION: Our results suggest that CL, CD and choice of sub-technique can be estimated from a signal similar to that obtained from dGNSS measurements tested on a roller ski treadmill. However, whether our findings also apply to testing in field needs to be elucidated. Hence, future studies should compare the performance of different approaches to this problem, including use of IMUs, dGNSSs, and combinations of them. If these challenges can be overcome, dGNSS can provide instantaneous performance outcome measures along with CL, CD and choice of sub-technique. REFERENCES Andersson, E. et al., 2010. Analysis of sprint cross-country skiing using a differential global navigation satellite system. European Journal of Applied Physiology, 110(3), pp.585–595. Fasel, B. et al., 2015. An inertial sensor-based system for spatio-temporal analysis in classic cross-country skiing diagonal technique. Journal of Biomechanics, 48(12), pp.3199–3205. Gilgien, M. et al., 2014. The effect of different global navigation satellite system methods on positioning accuracy in elite alpine skiing. Sensors, 14(10), pp.18433–18453. Gilgien, M., Haugen, P. & Reid, R., 2016. A new instantaneous performance parameter for alpine skiing and individual sports. Oral presentation at European College of Sports Science. Losnegard, T., Myklebust, H. & Hallén, J., 2012. Anaerobic capacity as a determinant of performance in sprint skiing. Medicine and Science in Sports and Exercise, 44(4), pp.673–681. Myklebust, H., Gløersen, Ø. & Hallén, J., 2015. Validity of Ski Skating Center of Mass Displacement Measured by a Single Inertial Measurement Unit. Journal of applied biomechanics.

Heart rate profiles, external work rate and kinematics when ski skating on varying terrain during low, moderate, and high-intensity endurance training

Haugnes Pål, Kocbach Jan , Luchsinger Harri , Munkebye Øyvind , Ettema Gertjan , Sandbakk Øyvind

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INTRODUCTION: The endurance-training model utilized in cross-country (XC) skiing consists of large amounts of low-intensity training (LIT) supplemented with low to moderate volumes of moderate- (MIT) and high-intensity training (HIT). During XC skiing competitions, the exercise intensity, as well as speed, work rates and kinematics fluctuates largely across the varying terrain. However, it is presently not known to what extent this occurs during ski-specific training

at different training intensities. The aim of the present study was therefore to investigate speed and heart rate profiles, as well as work rate and kinematic patterns in XC skiers while skating on snow in varying terrain at LIT, MIT and HIT. METHODS: Seven elite male Norwegian junior XC skiers (age 18.3±0.5 years, body height 180±6 cm, body mass 76.8±6.4 kg, peak oxygen uptake 67.2±5.6 ml·kg-1·min-1) performed two 20-m maximal velocity (Vmax) tests in both flat and uphill terrain monitored by photocells while skiing outdoors in the skating technique. This was followed by three 5-km in a competition track where they based on their own perception of intensity, were instructed to perform LIT, MIT and HIT, respectively, wearing a heart rate monitor and an inertial measurement unit (IMU) coupled to a global navigation satellite system (GNSS). RESULTS AND DISCUSSION: Mean speed increased with higher intensity ($P < 0.05$). The skiers' speed, work rate and heart rate were increased in uphill terrain compared to flat and downhill at all intensities, and these factors increased significantly with higher intensity in all terrains ($P < 0.05$), except speed and work rate from MIT to HIT in flat terrain. Thus, due to these terrain-dependent intensity fluctuations, the skiers performed at higher intensity than instructed in uphill terrain, particularly during LIT and MIT. Furthermore, this was followed by elevated cycle rate and length uphill at higher intensity ($P < 0.001$), except for cycle length that did not increase from MIT to HIT. On flat terrain cycle rate was significantly higher with HIT compared to MIT and LIT ($P < 0.05$). Uphill Vmax correlated strongly with uphill speed during HIT ($r = 0.78$, $P < 0.05$), whereas no relationship was found between flat Vmax and speed at any intensity in flat terrain. CONCLUSION: This study revealed that XC skiing in terms of metabolic intensity and external work rate is clearly interval-based, and that the kinematic pattern is adapted to the specific terrain and speed, when skiing across varying terrain. This applies even at low- and moderate training intensities and makes ski-specific training in varying terrain unique compared to most other modes of exercise where steady state intensities are obtained.

GPS and heart rate based analysis method for high level biathlon competitions

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INTRODUCTION: Biathlon is an endurance sport combining high-intensity cross-country skiing on hilly terrain with rifle shooting. Earlier studies have shown that high physical load before shooting influences negatively on parameters of shooting technique, especially in the standing position. Few studies in Biathlon exist today, especially with field measurements including heart rate (HR) during competition. Here we present a method for competition analysis in biathlon that can be used for individual guidance of athletes and in research. The work is based on a method previously applied in cross-country skiing, with the addition of the biathlon specific variables. METHODS: The analysis method is based on athletes wearing a global positioning system (GPS) device with integrated barometry and accompanying HR-monitor. The position data and altitude data for one athlete is used to define a standard course and altitude profile. Virtual split time positions are defined every 10-15 meters along the standard course. Additional virtual split times specific for biathlon are defined based on the GPS position and speed data. The HR data is used as a measure for cross-country skiing intensity and metabolic load during shooting. The analysis method was applied for 23 athletes in the women's class in the Norwegian championships sprint organized in mid-April. RESULTS AND DISCUSSION: The described method is feasible and has already been used for competition analyses of all individual biathlon sprint competitions on the highest national level in Norway throughout the 2015-2016 season

(Norwegian Cup competitions). The GPS and HR analysis makes it possible to study how different athletes vary speed and intensity in uphill, downhill and flat sections of the course, and specifically how they adjust speed and intensity prior to shooting. The maximum relative HR for the three laps increased from 92±2% on lap 1 to 94±2% on lap 2 ($p<0.01$) and further increased to 95±2% on the final lap. This was significantly higher compared to the second lap ($p<0.05$). On average, HR sank 1±1 percent points (pp) from maximum HR on lap 1 to the measurement just before shooting ($p<0.01$) and 2±1pp ahead of the second shooting ($p<0.01$). During shootings the relative HR was reduced with 16±4pp during prone ($p<0.01$) and 10±3pp during standing ($p<0.01$). The average hit rate was 81±23% and 74±20% during prone and standing shooting, respectively. No relationship was found between relative HR immediately before shooting and shooting result during prone ($p=0.97$) or shooting in the standing position ($p=0.23$). CONCLUSION: An analysis method applicable for high level biathlon competitions with minimal negative influence on athlete performance is presented. The method provides feedback of tactical choices and performance in different sections of the race to the athletes and coaches after the competitions. Additionally, the method provides valuable data for investigation of specific research questions.

Performance and perturbation tests in elite paralympic sit-skiers

Rosso Valeria, Gastaldi Laura , Rapp Walter , Lindinger Stefan , Vanlandewijck Yves , Fasel Benedikt , Pernot Dia , Linnamo Vesa

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INTRODUCTION: In cross-country sit-skiing, athletes are grouped in 5 different classes (LW10-LW12) on the basis of their ability to control the trunk. The greater trunk stability and trunk flexion angle during the pushing phase are, the higher is the performance effectiveness (Rapp et al.,2016; Schillinger et al.,2016). Since the aim of classification process is to move from functional to evidence-based classification, the purpose of this study is to design a new testing device and assess its reliability in measuring athletes sport-specific force production and trunk control. METHODS: The testing device is composed of a chair surrounded by an aluminum frame and fixed to a motorized sledge. Two force sensors are mounted in anterior and posterior backrests of the chair. Two force sensors are embedded in a couple of ropes fixed at the frame top. Athletes performance was tested by 3 maximal voluntary contraction tests: simulated bench press by pushing with (Pw), without (Pwo) back support and simulated poling by pulling (P); while athletes trunk control was assessed by unpredictable forward and backward perturbations. To assess reliability 12 sit-ski athletes classified LW10.5-LW12 performed each test twice in 3 days. The following variables were considered to test reliability: anterior force in Pwo, anterior and posterior force in Pw, pulling force in P and ratio between anterior force in Pwo and Pw. Perturbation data is yet to be analyzed. RESULTS: Considering all the athletes, all variables showed a high ICC (0.93, $p<.001$ anterior force Pwo; 0.98, $p<.001$ anterior force Pw; 0.95, $p<.001$ posterior force Pw; 0.93, $p<.001$ pulling force P; 0.77, $p<.03$ anterior force ratio Pwo/Pw). No significant differences were observed between the two tests in any of the measured force variables. When class LW10.5 (N=1) was combined with LW11 (N=2) the ratio Pwo/Pw (mean of two measurements) was lower (0.39 vs 0.53) than in combined LW11.5 (N=3) and LW12 (N=6). DISCUSSION: The high repeatability in sport-specific tests suggests consistent measurement conditions, thus the device can be recommended for force measurements in sit-ski athletes. Lower force ratio in lower classes supports the importance of trunk muscles. This

implies also that the new device can separate athletes with different impairment level. CONCLUSION: The next step is to evaluate if unpredictable perturbation test gives as good repeatability results as performances tests and if a trunk control-performance relationship is present. REFERENCE: Rapp, W., Rosso, V., Ohtonen, O., Gastaldi, L., Vanlandewijck, Y., Lindinger, S., Linnamo, V. (2016). Role of muscle activation in the sit-skiing performance and classification process. In Science and Nordic Skiing III (pp. 165–172). Schillinger, F., Rapp, W., Hakkarainen, A., Linnamo, V., Lindinger, S. (2016). A descriptive video analysis of classified Nordic disabled sit-skiers during the Nordic World Championship 2013. In Science and Nordic Skiing III (pp. 173–179).

Determination of the second lactate threshold in Norwegian ice sledge hockey players during upper-body poling

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Background: The second lactate threshold (LT2) is commonly used in the prescription of exercise intensity, separating moderate from high intensity exercise. This has not been well elucidated in Paralympic sitting sport athletes, who purely use their upper-body for propulsion in which the production and metabolism of lactate may differ as compared to leg exercise. In the only study on paraplegic wheelchair basketball players being tested in their court wheelchairs on a treadmill, the LT2 was identified at 2.5±0.8mmol/L corresponding to 76±9% of VO2peak and 15 in the rate of perceived exertion (RPE) (Leicht et al., 2014). However, to provide a better understanding of the LT2 in Paralympic sitting sport athletes this needs to be further examined in other modes and Paralympic populations. Therefore, the aim of this study was to determine the LT2 with the Dmax method during upper-body poling in ice sledge hockey players of the Norwegian national team. Methods: 15 endurance-trained ice sledge hockey players of the Norwegian national team (27±9 yrs, 71±8kg, 1.7±0.1m) performed an incremental test to exhaustion on day 1, followed by seven to eight 5-min stages at stepwise increasing effort on day 2 in a sport-specific upper-body poling mode. In all cases, pulmonary oxygen uptake (VO2), heart rate (HR), blood lactate (BLa) taken from the fingertip, RPE and average power output were measured. Peak values of these variables were determined as the highest values obtained during the incremental test. The individual LT2s were identified with the modified Dmax method (Bishop et al., 1998), and VO2, HR, BLa, RPE and power output were interpolated. Results: A lactate concentration of 5.9±1.4mmol/L (95%CI: 5.1-6.7, peak BLa: 13.4±2mmol/L) was identified at LT2, corresponding to 76±10% of VO2peak (95%CI: 70-82%; VO2peak: 35±7(mL/kg)/min), 79±7% of HRpeak (95%CI: 75-83%; HRpeak: 189±7beats/min), an RPE of 15±2 (95%CI: 14-16; peak RPE: 19±1) and a power output of 80±24W (95%CI: 67-93; peak power output: 135±30W). Discussion and conclusions: A considerably higher lactate concentration at LT2 was identified in our study as compared to Leicht et al. (2014), whereas %VO2peak and RPE values were similar. The higher estimation of the LT2 in our study as compared to Leicht et al. (2014) may partially be explained by differences in test modes (poling vs. wheelchair treadmill, respectively), in test participants (athletes with paraplegia, spina bifida and amputation, respectively vs. paraplegics) and in lactate collection site (fingertip vs. earlobe, respectively). Furthermore, the large CIs suggest large individual variations in lactate threshold, at least using this method. However, whether this variation is influenced by disability and if the use of the LT2 using the Dmax method is a valid indicator of maximal sustainable performance needs to be

examined further. References Bishop et al. (1998). Med. Sci. Sports Exerc. Leicht et al. (2014). Eur. J. Appl. Physiol.

A systematic race course analysis and a description of men's race performance in Paralympic alpien skiing World Cup Slalom and Giant Slalom Races of the seasons 2014/15 and 2015/16

Bruhin Bjoern, Senn Isabelle , Flury Silvia , Wolfsperger Fabian , Boffi Geo , Lorenzetti Silvio

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Introduction There are endogenous and exogenous factors, such as slope characteristics, course setting and snow conditions, on those an athlete's performance depends in competitive alping skiing (Turnbull, Kilding, & Keogh, 2009). Competitions in Paralympic alpine skiing are complex, because athletes with different disabilities compete against each other in the same category. There are three categories (visually impaired; standing; sitting) and 19 Sport classes (SC). To compare the performance of the athletes the real time is multiplied by a SC-specific factor. Research about slope, course setting and snow conditions and their influence on the performance in competitive disabled alpine skiing is missing. The primary aim of this study is to describe slope characteristics, course setting and snow conditions for a complete run (CR) and for intermediate sections (IS) in giant slalom (GS) and slalom (SL) World Cup races of the seasons 2014/2015 and 2015/2016. As secondary aim the mens inter-SC differences in the performance regarding steepness, course setting and snow conditions have been characterized. Methods Measurements were taken at six sites during seasons 2014/2015 and 2015/2016. Slope steepness and course setting were measured with a Global Positioning System device while snow parameters were measured with a modified ram penetrometer and with a pocket thermometer. As performance parameter the ratio between the IS (or CR) of the athlete divided by the best IS time of the category (or the best time of the CR of the category) was used. The IS time of each athlete was captured by high-speed video recording, whereas the official result lists were used for the CR times. Results The course setting seems to be influenced by the slope terrain. In flat IS the course was set straighter, contrary to steeper slopes where a more sinous course was chosen. In general the difference between SC are smaller on CR compared to the IS. The mean values of the categories 2015/16 are higher than 2014/15. Steep courses and sinuous course setting provoke bigger differences between SC. Conclusion A reason for a wider and straighter course setting, compaired to non-disabled skiing could be that the course setting has to suit all athletes. The study demonstrates differences in the performance of different SC regarding certain slope and course setting conditions. The results demonstrate the challenge of organizing completely fair conditions in disabled skiing and the complexity of developing an appropriate classification system, a common problem in Paralympic sports (Tweedy & Vanlandewijck, 2011). References Turnbull, J. R., Kilding, A. E., & Keogh, J. W. (2009). Physiology of alpine skiing. Scand J Med Sci Sports, 19(2), 146-155. Tweedy, S. M., & Vanlandewijck, Y. C. (2011). International Paralympic Committee position stand, background and scientific principles of classification in Paralympic sport. British Journal of Sports Medicine, 45(4), 259-269.

External forces in alpine sit-skiing vs. athletes' strength abilities – consequences for development of evidence-based classification

Goll Maren, Spitzenpfeil Peter , Olvermann Matthias , Huber Andreas

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INTRODUCTION The current IPC Alpine Skiing classification protocol for sit-skiers comprises the assessment of trunk muscular power impairment, neurological impairment and a functional presentation. All tests return ordinal-scaled values, unsuitable for the development of evidence-based classification. Hence, a process-focused research approach is necessary to determine the biomechanical activities with the greatest impact on performance (1). The purpose of the study was to analyze the sport of sit-skiing in order to identify the relevant areas for the development of standardized and sport-specific measures of performance for evidence-based classification. METHODS Actions and interactions in sit-skiing were evaluated focusing on two areas: general strength ability was assessed in maximum isokinetic and maximum isometric tests on an isokinetic strength testing device (Isomed2000, D&R Ferstl, GER); and vertical ground reaction force was calculated from the athletes' spring/ suspension-unit in giant-slalom field testing (2D Datarecording, GER). RESULTS Mean (±SD) strength values for female athletes were 56.5 ± 8.5 Nm for left sided rotation, 50±12 Nm for right sided rotation, 68.6±19.5 Nm in flexion and 41±15 Nm in extension. Male athletes reached 85.7 ±27.4 Nm for right side rotation, 107.3±41 Nm for left side rotation, 125.7±48.7 Nm in flexion and 78.7±71 Nm in extension. Strength capacities decreased with an increase in the athlete's respective activity impairment. Mean (±SD) ground reaction force for all athletes of 1.9±0.5 g was calculated, peaking in maxima in a range from 3.2 g up to 5.0 g. Ground reaction force showed a pronounced pattern of lowest values during the turn's initiation phase. CONCLUSION General strength abilities were low in general. A low strength performance was attended by a high level of activity impairment. However, ground reaction force values in Giant Slalom are comparable to values reported for standing alpine Giant Slalom skiing (2). Thus, the interrelation of strength capacities and ground reaction forces leads to two components of relevance for the development of standardized measures of performance: Firstly, equipment used and its impact on trunk stability. Secondly, turn initiation phase, which is the sensitive phase for sit-skiing with high importance of sensorimotor abilities to position and control COP within the support base. REFERENCES 1) Tweedy, S. M.; Vanlandewijck, Y. C. (2011) International Paralympic Committee position stand--background and scientific principles of classification in Paralympic sport. British Journal of Sports Medicine 45(4):259–269. 2) Spörri, J., Kröll, J., Haid, C., Fasel, B. & Müller, E. (2015). Potential Mechanisms Leading to Overuse Injuries of the Back in Alpine Ski Racing: A Descriptive Biomechanical Study. The American Journal of Sports Medicine, 43 (8), 2042–2048.

Fair, equal, safe and universal equipment in parasports - experiences from development of a sit-ski and lower leg prosthesis for Cross Country skiing

Danvind Jonas, Ohlsson Marie, Skoglund Per

Sports and recreational equipment for people with a disability is a prerequisite for health and inclusion through physical activity, sports and outdoors activities. The accessibility of equipment is very low on the global level and therefore it is an international societal challenge. The objective of this work is to provide the engineering society with an understanding of factors influencing the equipment development for parasports, from grass-roots to elite level. The

methodology of this work has primarily been the authors' evaluations of own experiences of equipment development in parasports in relation to references and discussions thereof. Two equipment products were exemplified and parameters in relation to their development were summarised. The results showed that the meaning of "fair and equal" for elite level equipment was not understood early in the product development process, which led to a technological dispute and the rejection of the lower leg prosthesis for Nordic skiing skate technique for competing on the Paralympic level. The cross-country sit-ski, that was developed more for the leisure market, had a greater balance in the demands from different stakeholders. In conclusion, it was suggested to invite sport equipment stakeholders to share values and requirements early in the equipment design process. Functional products and modular equipment, primarily for the leisure market, were encouraged for future access to and development of low-cost equipment on a global level. A multi-disciplinary technology collaboration platform and engineering design guidelines were suggested for technology clarification and the development of fair, safe and universal equipment design.

Kinematic and kinetic analysis of a Paralympic skier during Slalom

Petrone Nicola, Marcolin Giuseppe , Piccinin Davide , Kersting Uwe , Dziewiecki Michal , Wisser Anne , Supej Matej

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INTRODUCTION: Paralympic skiing is a skiing discipline that is emerging not only in the paralympic competitions but also in recreational areas, with growing attention mostly from the physiological point of view (Goll, 2015). Monoskis or dual skis are complex equipment where the design and tuning of the suspension system, the ergonomics of the seat and the personalized setup of the mass distribution influence performance and safety of the skier. The aim of the study was to extend the knowledge on skiing technique and monoski behavior through kinematic and kinetic data. METHODS: A paralympic monoski "Scarver" (Tessier®, FR) was equipped with a dynamometric binding plate to measure forces acting in a normal and lateral direction with respect to the ski plate and the pitch moment acting about an axis transverse to the ski (Petrone,2014). The Italian National Champion of giant slalom was tested. The monoski shell was conformed to his anatomy and level of spine injury. The athlete was wearing a motion capture suite (Xsens, NL) and two additional IMU sensors applied to the outer seat and to the ski binding. The trajectory of the skier and the location of the slalom poles were surveyed by a RTK GNSS system (Leica, CH) with a reference station at the top of the course and the rover on the athlete's back. The systems were synchronized by a set of jumps. The athlete performed three runs in a narrow and a three in a wide slalom course on a moderate slope. RESULTS: The reference trajectory surveyed by the GNSS system was fused with the body motion capture data. This allowed to precisely analyze the skier's segments motion as well as the monoski-skier center of mass (CoM) kinematics. The dynamometric platform retrieved ground reaction forces (GRF) and moments, the center of pressure (CoP) location along the ski and their variation with speed and the slalom course offset. Peak values up to 2.75 times the total weight (athlete+monoski) were consistently recorded as well as mean excursions around than 120 mm of the CoP during the slalom turns. DISCUSSION: The collected kinetic data enable understanding skiing dynamics and its correlation with the athlete's posture and movement. Data are also of interest to the monoski manufacturers towards the development of lighter and safer assistive devices for skiing. CONCLUSION: The innovative measurement system enabled analyzing the GRF applied at

the binding of a race paralympic skier when performing two different slalom courses on the same slope and to provide insight into the skier's skiing technique with respect to the control of the CoM and the CoP at the ski bindings. ACKNOWLEDGEMENTS: ISEA Wintercamp 2015, Tognola skiing resort, San Martino di Castrozza, IT. REFERENCES: Petrone N., Marcolin G., Cognolato, M., Hofer, P., Nachbauer, W. (2014), Proc. Eng., 72, pp. 630-635. Goll, M., Wiedemann, M.S.F., Spitzenpfeil, P., (2015) Journal of Sports Science and Medicine, 14 (4), pp. 819-824.

Knee torque of an above-knee prosthesis for two-track alpine skiing

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INTRODUCTION: The objective of the study was to analyze the knee joint dynamics during two-track alpine skiing of the persons with an above-knee amputation and the influence of the additional load on the torque in the prosthesis and the intact leg. METHOD: The study examined a subject with an above-knee amputation of his right leg. He uses an above-knee artificial limb with a special multiple-axes prosthetic knee joint ART-LEG Sport Knee (Art-leg, Ljubljana, Slovenia). Measurements of kinematics and dynamics parameters of both legs during consecutive two-legged squats used to simulate skiing movement through a turn were carried out in a purposely-built test device, allowing changes of additional vertical loading in terms of body weight fractions (BW) (Demšar et al., 2015). Knee joint flexion angle (ϕ_K) was represented by the angle between the lower and the upper leg. Change of Flexion Angle (CoFA) was calculated as the differences between the largest measured angle and a momentary angle. The torque in the knee joint (T_K) was calculated by means of inverse dynamics. RESULTS: On the prosthesis side (right leg), the average knee torque in the starting (upper) position was between 0.44 ± 0.06 Nm/kg (+0/3 BW) and 0.46 ± 0.04 Nm/kg (+3/3BW). The maximum torque was achieved at the maximum CoFA (lower position). The average values were between 1.16 ± 0.03 Nm/kg (+3/3 BW) and 1.36 ± 0.04 Nm/kg (+0/3BW). In the intact (left) leg, the average knee torque in the upper position was between 0.53 ± 0.14 Nm/kg (+0/3 BW) and 0.83 ± 0.20 Nm/kg (+3/3BW). In the lower position, the average knee torque was between -0.23 ± 0.16 Nm/kg (+0/3 BW) and 1.32 ± 0.17 Nm/kg (+3/3BW). DISCUSSION: On the prosthesis side, a rather linear connection between torque and flex in the knee prosthesis can be observed. It reaches its maximum value at the maximum flex. The additional load has no influence on the torque value in the knee prosthesis. On the intact leg side, a typical drop in torque can be observed in the flexing stage. It reaches its minimum value a little before the lower point. After that, knee torque raises sharply, followed by gradual drop towards the starting value. In case without additional load (+0/3BW) and additional load of one thirds of body weight (+1/3 BW), the negative (flexion) torque is required to flexing the prosthesis. By increasing the added load, torque in the intact knee increases. CONCLUSION: The above-presented results can lead to the conclusion that in case of an amputation, the intact leg will adapt to the prosthesis, and they will together form parameters, close to those of an intact body. REFERENCES Demšar, I. et al., Multi-Axis Prosthetic Knee Resembles Alpine Skiing Movements of an Intact Leg. Journal of sports science & medicine, 2015. 14(4): p. 841.

Biomechanics and physiology of contemporary cross-country skiing

Stöggl Thomas

Especially the introduction of sprint races and the increased amount of mass-start races brought new aspects of training, testing and skiing technique into the field of cross-country skiing (XCS) research. Tactical aspects, the ability to accelerate in intermediate sprints and recover in between those and the ability to reach high speeds in the finishing spurt reached greater importance and constitute race decisive factors. Current studies reported technical modifications by skiers to either adapt to documented higher racing speeds and consequently very short ground contact times (e.g. ~200 ms for the poling phase) or that led to these increased speeds. Associated with this, a new sprint double poling (DP) technique was proposed a decade ago [1], which was further developed within the past years [2,3], as well as the transfer of the "double-push" (DPU) technique adapted from inline speedskating to XCS [4,5], and first scientific analyses of the running/jumping diagonal stride [6, 7] and the jumped V1 technique [8]. As a first example, during classical XCS, the DP technique has drastically developed, with several to date elite skiers employing this technique successfully throughout an entire race. This development began in connection with popular long-distance races, which consist primarily of flat and slightly uphill terrain, as well as the short sprint races. However, since the past seasons, certain skiers also began to successfully utilize exclusively DP during longer WC distance races. This revolution has many causes including better track preparation, improvement of equipment (pole properties, gliding properties of skis), greater upper-body strength and endurance capacities, and substantial biomechanical and skiing technical improvements [3]. Obvious gains in this context are that skiing without kick wax provides better glide and is more economical on certain sections of the course. In this context, several studies have demonstrated that longer poles were related to DP performance [9-12] and/or O2 cost in flat [10] and especially uphill terrain [10,11]. However, this development was largely debated within the past years, and as an attempt to condemn this development the 83% maximal pole length FIS rule was introduced for the season 2016/17. As another example, XC skate skiing has evolved markedly over the years, with more explosive subtechniques being developed. Although V1 skating has been shown to be faster than V2 skating on steep uphill inclines [13], on less steep inclines or on flat terrain higher speeds can be reached using DPU [4, 5]. To be mentioned here, that current skating skis are not developed for the use of the DPU technique. Therefore, new ski geometries and material properties have to be developed to support DPU skating (e.g. using the technique without a jump). In this context, a recent patent on skating skis was submitted which greatly differs from standard skating ski geometries and material properties (Stöggl, 2015). 1.Holmberg H-C, et al. 2005, MSSE 2.Stöggl T, et al. 2016, MSSE 3.Stöggl T, et al. 2011, SJMSS 4.Stöggl T, et al. 2008, JSS 5.Stöggl T, et al. 2010, MSSE 6.Stöggl T, et al. 2011, SJMSS 7.Stöggl TL, et al. 2009, MSSE 8.Stöggl T, et al. 2015, MSSE 9.Nilsson J, et al. 2003, SBiom 10.Losnegard T, et al. 2016 IJSPP 11. Losnegard T, et al. 2016 ICSS 12.Stöggl T, et al. 2010, JSS 13.Kvamme B, et al. 2005, EJAP

Influence of upper body anaerobic pre-load exercise on energy metabolism and performance in an alpine ski-specific box-jump test

Sieder Mario , Müller Alexander , Hofmann Peter , Tschakert Gerhard

Introduction The aim of this study was to examine the effect of an additional high-intensity upper body pre-load exercise (hand crank) on energy metabolism and performance on a subsequent anaerobic ski-specific exercise test (Box-Jump). Several studies showed that an elevated systemic lactate concentration due to a high-intensity exercise of non-dominant muscle groups significantly reduced net lactate increase during subsequent anaerobic exercise. This inhibition of lactate production shifted metabolism to a more dominant oxidative one and enhanced high-intensity exercise performance (1-4). Methods Twelve male junior alpine skiers (age: 18.3±1.7 yrs; weight: 77.4±7.5 kg) performed the 90-second Box-Jump (height: 37cm; wide: 50cm) in two trials in a randomized order either without or with a 30-35-second all-out hand crank pre-load exercise with one week between tests. Lactate (Biosen-S-line, EKF-Diagnostics, GER) was measured at 11 specific time points by means of capillary samples (20 µl) from the ear lobe. Heart rate (Polar Electro, FIN) was measured continuously. Performance (total number of jumps) and jump frequency were obtained by means of video based recordings. The Borg rating of perceived exertion scale was used to measure the exertion after the pre-load, before and during the Box-Jump test. Results The systemic lactate increase after the high intensity hand crank exercise 23 (8.24±1.63mmol/l) was significantly elevated compared to the no pre-load conditions (1.1±0.32mmol/l). Net lactate accumulation during the Box-Jump test was significantly reduced ($P \leq 0.005$) by 32% with the hand crank pre-load exercise. Performance (no pre- load: 107.33±3.75 jumps; pre-load: 107.58±5.2 jumps), perceived exertion and jump frequency showed no significant differences between conditions. Conclusion In general the systemic lactate elevation by means of a high-intensity anaerobic pre-load with non-specific upper body muscles had no negative influence on leg Box-Jump performance. In line with other studies (1, 2, 4) the results of our study indicate a possible performance-enhancing capability. The pre-elevated lactate level inhibits lactate production and shifts metabolism to a higher oxidative one in a subsequent high-intensity anaerobic exercise bout. This concept of the lactate induction by non-dominant muscle groups (3) may enhance performance in alpine ski racing and other high-intensity sports but several aspects especially regarding neuro-muscular function and sport specific technique need to be addressed in further studies. References 1) Almer Ch. et al.: In: Radmann, et al. (eds.): ECSS Malmö 2015: 532. 2) Birnbaumer et al.: In: Baca, et al. (eds): sportools. 2016: 198. 3) Hofmann et al.: In: Baca, et al. (eds.): sportools. 2016: 456. 4) Müller, et al.: In Müller et al. (eds.). Science and Sking VI. Meyer and Meyer Sport (UK) 2014: 224-230.

Injuries and illnesses in elite youth alpine ski racers and the influence of biological maturity and relative age: a two season prospective study

Müller Lisa , Hildebrandt Carolin , Raschner Christian

INTRODUCTION: Alpine ski racing is a sport with a high risk of injury. However, a lack in scientific research is that of monitoring and preventing injuries at the youth level. (Spörri et al., 2016) Additionally, biological immaturity and the relative age combined with the year round training may lead to specific health and injury patterns in youth ski racing. Therefore, the aim of the present study was to monitor traumatic (TI) and overuse injuries (OI) and illnesses (IL) of elite youth ski racers (YSR) and to assess correlations with biological maturity and RA, as well as gender specific differences. METHOD: In total, 82 elite youth ski racers (51 males, 31 females; 9-

14 years) of a ski boarding school in Austria participated in this study. A prospective longitudinal cohort design was used to monitor anthropometrics, training characteristics and TI, OI and IL over two consecutive seasons. Frequencies were calculated; chi²-tests were used for comparisons concerning categorical variables. The level of significance was set at $p<0.05$. RESULTS AND DISCUSSION: A total of 2020 training sessions (922 skiing, 1098 athletic) were analyzed. 266 medical problems were recorded. Among the 82 YSR, 42.7% were affected by TI, 10.7% by OI and 84.1% by IL; 8.5% reported no medical problems (NO-MP). A total of 52 TI were recorded, which were mainly classified as moderate (time loss of 8-28 days) and mostly affected the knee (34.4%), followed by the ankle joint (11%). The highest rate of TI was reported in January (26.9%). In total, only 17 OI were described from 13 athletes. Most of the OI affected the knee (83%) and were categorized as moderate or severe (time loss of >28 days). 69 athletes reported IL, which resulted mostly in less than 4 days absence from training. Athletes of the last relative age quarter (Oct-Dec; Q4) had a significantly higher chance of having NO-MP ($\chi^2=5.746$; $p=0.017$) compared to relatively older YSR. No significant gender specific differences were present in the occurrence of TI, OI and IL; however, among athletes with NO-MP a significant gender specific difference was present with females representing a higher chance of having NO-MP ($\chi^2=5.775$; $p=0.016$). No significant differences in the occurrence of TI, OI and IL were present between normal, early and late maturing athletes. CONCLUSION: A high rate of TI and IL was present among YSR. Only few OI were recorded, which shows that a lot of preventive measures were applied and that the training load was adequate. The high rate of illnesses could be due to the life with age-matched pupils in the boarding school. Female athletes and athletes of Q4 represented a higher chance of having NO-MP. The biological maturity status did not significantly influence the occurrence of MP. REFERENCES: Spörri, J., Kröll, J., Gilgien, M., Müller, E. (2016). How to Prevent Injuries in Alpine Ski Racing: What Do We Know and Where Do We Go from Here? Sports Medicine, doi:10.1007/s40279-016-0601-2.

Ski turn kinematics: a comparison between downhill skiing and training on skiing simulators

Woznica Wojciech , Szymanska Dominika A.

INTRODUCTION: Devices and even whole systems designed to simulate skiing conditions, or at least allowing to recreate the ski turn movement patterns, are becoming more common nowadays. They can be found at ski resorts that wish to provide a whole-year tourist offer, in cities located at a large distance from the mountains and in sports facilities where they are used by professional athletes as part of their pre-season training routine. With such a variety of constructions, a question arises: how much does the movement performed on these devices reflect the movement of a skier on the slope? METHOD: The study group comprised 5 male ski instructors (age: 24.6±3.5 y.o.; h: 1.87±0.06m; BM: 83.8 ±7.3kg): 4 at level 4 EQF and 1 at level 5 EQF. The examined men performed ski turns and ski turn-alike movements in the following conditions: skiing (SKI), on a revolving slope (RSS), on a SkyTechSport Ski Simulator (ST), on a ProSkiSimulator (PSS) and on a Skier's Edge (SE). All trials were performed with the subjects wearing ski boots. The kinematic data were obtained using a 3D motion capture inertial measurement myoMOTION Research Pro HS system (Noraxon Inc., Arizona, USA). These data were collected at a frequency of 200 Hz, since this frequency represents the maximum sampling rate of this set-up. 7 sensors were placed symmetrically on the dorsal surface of the feet, shanks,

thighs and on the sacral area. Continuous records were divided into cycles of movement. A single cycle threshold was defined as the maximal lean of the internal leg shank into the centripetal configuration. RESULTS: The lean of the internal leg shank into the centripetal configuration while skiing amounted to 51°. Only when exercising on ST was a similar range of motion in the frontal plane achieved (up to 48°). While training on other devices, the level of angulation did not exceed 20-35°. The flexion-extension movement in the hip during skiing ranged from 40 to 110°, whilst in other training devices, the recorded minimum was 15° and the maximum was 90°; however, the range of motion itself did not transcend 20-40° depending on the device. The knee flexion-extension range of motion during skiing was within the limits of 35-90°, but the biggest range of motion was recorded during exercises on PSS and SE (15-90°). DISCUSSION/CONSLUSION: The range of motion in the frontal and saggital plane in lower limbs joints and in the centripetal configuration of the body was usually the widest while skiing. The kinematic parameters closest to those achieved in the case of skiing were generally the ones recorded while exercising on ST. SE and PSS devices are limited in recreating the kinematic parameters of skiing by their construction based on rubber bands and exercising in a closed kinematic chain (hands holding the handrail).

Comparative electromyography analysis of skiing on slope and in simulating conditions

Szymanska Dominika A. , Woznica Wojciech

INTRODUCTION: The goal set for ski simulators and training devices is to recreate the movement patterns and physical effort characteristic for skiing in the most reliable way. Due to the fact that these devices do not recreate external forces acting on the skier's body, it seems reasonable to determine the extent to which the muscle electrical activity characteristics of the skier exercising on these devices are similar to those in the actual skiing conditions. METHOD: The study group comprised 5 male ski instructors (age: 24.6±3.5 y.o.; h: 1.87±0.06m; BM: 83.8 ±7.3kg): 4 at level 4 EQF and 1 at level 5 EQF. The examined men performed ski turns and ski turn-alike movements in the following conditions: skiing (SKI), on a revolving slope (RSS), on a SkyTechSport Ski Simulator (ST), on a ProSkiSimulator (PSS) and on a Skier's Edge (SE). All trials were performed with the subjects wearing ski boots. The EMG signals of four muscles of interest were selected on both legs: rectus femoris (RF), vastus medialis oblique (VMO), biceps femoris (BF) and tibialis anterior (TA). Electrode placement and skin preparation were performed in accordance with the SENIAM protocol (Hermens et al., 2000). The EMG signals were recorded (1.5kHz) using the 8-channel, wireless Telemyo DTS system (Noraxon Inc., Arizona, USA). The MVC was measured for 5 s in the most appropriate anatomical and functional joint angle producing the highest force output – the recorded data were used for signal adjustment. The EMG data obtained in the experiment were rectified and normalized. Afterwards, the whole record was divided into cycles of movement. A single cycle threshold was defined as the maximal lean of the internal leg shank into the centripetal configuration. RESULTS: The highest level of muscle activation was obtained when skiing on slope during which the activity of the anterior compartment of thigh muscles exceeded 100% MVC. It turned out that VMO was the most active among all the examined muscles; during all exercises its amplitude raised over 100% MVC and also, in the ST and SKI conditions, it amounted to 180-200% MVC. Except for skiing, RF was active at a similar level of 40-80% MVC on all devices. The TA activity in PSS and SE did not exceed 40% MVC, but in ST it

reached 50-60% MVC. DISCUSSION/CONSLUSION: The level of the muscle activation is to some extent determined individually; however, there is a noticeable characteristic of muscle activity which diversifies exercises in different conditions. Sky Tech is a device the activity characteristic of which is the most similar to skiing; when training on other appliances, subjects did not reach similarly high values of the EMG amplitude. REFERENCES Berg HE, Eiken O. Muscle control in elite alpine skiing. Med Sci Sports Exerc. 1999 Jul;31(7):1065-7 Panizzolo FA, Petrone N, Marcolin G: Comparative analysis of muscle activation patterns between skiing on slopes and on training devices. Procedia Engineering, 2, 2010, 2537-2542

A fundamental study on deformation behavior of ski and snow surface

Hashimoto Yuto , Sakanaga Hiroyasu , Kagawa HIroyuki , Yoneyama Takeshi , Nikki Kunio , Abe Osamu

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INTRODUCTION In order to elucidate the ski turn mechanism skier's motions and deformation behaviors of skis during skiing have been investigated at least in our group. Grasp of characteristics of snow and sliding resistances from snow surface must be done for the further study. In this study the indentation resistance, which is inseparably related to the ski deformation during skiing, is especially focused on. We have already examined snow hardness by using a rigid indenter, and have experimentally revealed the effect on it of temperature, density, and grain size of the snow. The compaction area formed in snow just under the indentation has also been observed. For the basic study to make use of the results and predict ski's deformation during skiing, an elastic plate in substitution for the ski has been indented to the snow surface. METHODS In this experiment the snow surfaces with uniform density in the range of 300 to 500[kg/m3] were made of roughly spherical snow with uniform particle sizes and sintered overnight to harden. The experiments have been carried out under a constant temperature in the range of -15 to -1[°C]. Rectangular flat plastic plates of 150 x 50[mm] with a certain thickness were used as the indenters. To investigate the influence of rigidity of the plates, the thickness of the plates were changed into three ways of 1, 2, 3[mm]. A force measuring device attached to a single axis linear actuator pressed the center of each plate on the snow surface at constant velocity of 1[mm/s]. During the experiment loads and indentation depths were measured by using the force measuring device and the laser displacement sensor respectively. The contact area between the snow surface and the plate could be also measured because of using transparent plates. After the experiments the shapes of the indentations were measured. The section areas obtained by cutting the snow surface vertically were observed by the ink method. These experiments have been conducted in Shinjo cryospheric environment lab of NIED in Japan. RESULTS & DISCUSSION From the results of the indentation by elastic plates it found that the loads were roughly proportional to the fourth root of the indentation depths. This resembles an elastic beam problem for strength of materials that constant uniform pressure acts on one side of the beam that the center is supported. The surface shape of snow after the indentation almost accorded with the deformation of the beam. Furthermore, it found that the compaction area formed in snow to depth roughly 4 times as long as the depth of indentation. CONCLUSION To consider ski's deformation during skiing elastic plates as the model indented to snow surface. By this experiment we obtained knowledge about the deformation behavior of ski and snow surface. REFERENCES Hashimoto, Y., Hayasaki, R., Kagawa, H., Nikki, K., Abe, O.

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Development of a new 6 component force sensor design for biomechanical research in alpine skiing

Falda Thomas , Hintzy Frédérique , Rougier Patrice , Coulmy Nicolas , Lacouture Patrick

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INTRODUCTION: Measurement of the forces acting between the skier and the ground is a key parameter to understand alpine skiing performance. This can be achieved through several methods, the more precise of which being the use of force platforms (Lüthi, 2005). This study aimed to design and validate a new force platform design suitable for forces and moments measurement in alpine skiing. METHOD: A fully integrated 6-component force sensor was built as an interface between ski boots and bindings, with the sensors placed in front and behind the ski boot, rather than below it. This design was thought as a convenient answer to several drawbacks of existing platforms (Stricker, 2010): it allowed an easy adjustment to different ski equipment, kept increased height below 1cm, saved weight, and avoided unnecessary hardening of the ski or boot. The sensor was composed of a front and a rear part, connecting the ski boot to the front and the rear binding, respectively. Both parts were not linked, in order to save weight and to allow a convenient way to adapt to different ski boot's sole lengths. A first experiment was performed in order to compare forces (F), moments (M), and Center of Pressure (CoP) measured with a reference force platform (Kistler) and the new sensors. Hence, a subject wore the ski boot, with the ski being fixed onto a force platform. The subject performed movements to solicit all three axes. Then, a preliminary on-field study was performed. One subject performed short carving turns on a moderately inclined slope. RESULTS AND DISCUSSION: Root mean square error (RMSE) data of forces and moments obtained from the validation experiment were as follows: Fx: 2.10N; Fy: 1.32N; Fz: 11.5N; Mx:1.04N.m; My: 3.60N.m; Mz:0.28 N.m; CoP A-P: 0.47 cm; CoP M-L: 0.30 cm. The force pattern of the new sensors showed a high agreement with those of the force platform. RMSE values were slightly larger for Fz and My, which are typically the most solicited axes of forces and moments, respectively. The skiing experiment was used to obtain force-time pattern of the anterior-posterior (Fx), the medial-lateral (Fy) and the vertical (Fz) forces and moments while skiing. Values agreed well with previous reported data (Meyer, 2011). Fz on the outside ski reached 1200N, but only 800N on the inside ski. The peak on the outside ski was reached during the second half of the turn, while the vertical force on the inside ski quickly reached a plateau. Fx and fy forces were typically a lot smaller. CONCLUSION: The new innovative sensors allow a convenient and precise measurement of all forces and moments produced by the skier at the interface shoe / ski during the practice. REFERENCES: Lüthi, A. et al. (2005). In: proc of the 3rd Int congress on Science and Skiing. p96-106. Oxford: Meyer & Meyer Sport Ltd. Meyer, F. (2011). PhD Thesis, Lausanne, p. 167 Stricker, G. et al. (2010). Eur. J. Sport Sci. 10, 31–41.

Event preparation in 'middle-distance' events: Making practical sense of pre-conditioning and priming the body for competition day

Pringle Jamie

Middle-distance athletic performance (60s to 300s) characteristically demands both maximal mechanical muscle power and maximal anaerobic energy release, as well as attainment of peak rate of aerobic (i.e. cardiorespiratory) capacity. The transition, from at rest on the start line, to maximal intensity exercise within seconds, and typical of such events, is highly demanding, but also provides unique insight to the capacity, conditioning and pliability of physiological systems and pathways. The purpose here is to highlight the potential to adjust or optimize those pathways through practically achievable pre-performance interventions. Examples from summer and winter sports across the British World Class network illustrate how small changes in physiological capacity, that are identifiable through theoretical modelling, have been sought in practice by trialing pre-event methods, and have resulted in measurably altered performance. These gains arise from the manipulation of the metabolic, vascular and neural milieu – mostly of the (more pliable) muscle (but also cardiorespiratory and systemic factors e.g. endocrine) – through preparatory 'priming' exercise, or by 'pre-conditioning' in the hours or days before competition. Traditional explanations of anaerobic capability as a fixed and finite energetic capacity (e.g. accumulated oxygen deficit) are considered alongside contemporary understandings of muscle mechanical and fatigue characteristics, as well as oxygen uptake (VO2) kinetics. Faster VO2 kinetics at exercise onset allows a greater aerobic energy contribution, particularly in early exercise (<60s), and a greater total energy turnover. Methods that acutely improve muscle vasodilation and oxygenation, as well as effects at the mitochondrial enzymatic level, have potential performance benefit, and may be particularly relevant to the sprint performer with their lesser mitochondrial and vascular conditioning; or under ischaemic conditions (occlusive muscle forces and hypoxia/altitude etc). Of specific importance to sustaining maximal muscular performance may also be countering the respiratory muscle metaboreflex. Consequently, increasing muscle oxygenation may not just increase energetic turnover, but may also counter the adverse effects of ischaemia and improve high intensity muscle performance. Specific to the cold environment, consideration must also be given to retaining muscle temperature and the benefit this confers to mechanical power at the cross-bridge level, as well as to peripheral blood flow and oxygen extraction. Interventions can be adjusted to best suit the characteristics of the athlete and their event, but most critically, any method must consider the practicalities of the timeline to performance (incl. technical, tactical and psychological preparation) and the constraints of the competition environment. As such, the solution must be highly practical, flexible and pragmatic, and with minimal supervision to the athlete.

Minimal and non-invasive monitoring of the training and health of elite athletes using commercially available wearable and point-of-care technology

Sperlich Billy

Endurance athletes are exposed to varying training loads including high-intensity and/or high-volume exercise at different altitude and with different environmental conditions inducing significant muscular stress with the potential of impaired health. The athlete's individual monitoring of training load is essential for optimizing adaptation and performance and counteracting unwanted side effects such as overtraining symptoms or injury. Consequently, easy and fast determinable biomarkers should be assessed on a daily basis in order to alter the training load (volume and/or exercise intensity) when stress markers drift outside the normal

individual range of the athlete. In the past two technological advancements, i.e. point-of care testing (POCT) and numerous wearable sensor-based devices which are worn close to and/or on the surface of the skin have emerged to quantify biomarkers to monitor training load and health. In contrast to the more sophisticated biochemical laboratory analysis (e.g. muscle biopsies, special blood analysis) which are invasive, cost worthy and time consuming POCT (Sperlich, Achtzehn, de Marees, von Papen, & Mester, 2016) and wearables (Duking, Hotho, Holmberg, Fuss, & Sperlich, 2016) allow simple assessment of biomedical parameters which can be obtained and analysed on the training site and also provide information of activities of daily living. However, i) not every biomarker resembles as legitimate or sensitive variable for monitoring the stress of training (Halson, 2014) and ii) the variety of POCT devices and wearables is overwhelming and it is not clear which one(s) may be optimal for monitoring training and health (Duking et al., 2016). To address the aforementioned matter, this talk aims to i) summarize non-invasive (or minimal invasive) candidate markers for the daily assessment of training load and health; ii) discuss the practical applications of these variables for monitoring training load during iii) to briefly summarize devices of POCT and wearables presently available and the parameters they monitor; and iv) to highlight current gaps in our knowledge in order to help direct both future scientific studies and the development of POCT and wearables. Duking, P., Hotho, A., Holmberg, H. C., Fuss, F. K., & Sperlich, B. (2016). Comparison of Non-Invasive Individual Monitoring of the Training and Health of Athletes with Commercially Available Wearable Technologies. Front Physiol, 7, 71. doi:10.3389/fphys.2016.00071 Halson, S. L. (2014). Monitoring training load to understand fatigue in athletes. Sports Med, 44 Suppl 2, S139-147. doi:10.1007/s40279-014-0253-z Sperlich, B., Achtzehn, S., de Marees, M., von Papen, H., & Mester, J. (2016). Load management in elite German distance runners during 3-weeks of high-altitude training. Physiol Rep, 4(12). doi:10.14814/phy2.12845

Muscle fatigue during high-intensity exercise – an update

Ortenblad Niels

Muscle fatigue is a common experience during sport and exercise activities. The manifestations of fatigue, as observed by reductions in the ability to produce a given force or power, are readily apparent soon after the initiation of intense activity. Additionally, a sustained weakness may persist for hours or even days weeks following exercise. The mechanisms responsible for the impairment in performance are various, given the severe strain imposed on the multiple organ systems, tissues and cells by the activity, however, Its well understood at this time that fatigue is complex and intensity and task-specific (2). This is particular in high-intensity and repeated exercise as in many skiing disciplines (1, 3). Muscle fatigue, by definition arises at least in part from failure of cross-bridge cycling within the muscle cells (1, 3). However, the contractile machinery relies on multiple systems to support its work, including the neural activation, muscle excitation-contraction coupling, muscle bioenergetics, and contractile properties per se. Thus, failure at any of the sites upstream from the cross-bridges can and does contribute to the development of fatigue. In this symposium, the main objective is to address the mechanisms of fatigue at the muscle level, during and following high-intensity and/or repeated exercise, with special emphasis on skiing exercise. The muscle fatigue mechanisms are generally accepted as being at the level of muscle calcium regulation and ion balance, muscle metabolism and at the contractile apparatus. These possible mechanisms of muscle fatigue will be covered addressing

the advances made in characterizing the basis of muscle cell contractility and how these processes can be modified during repetitive activity and affect performance. REFERENCES: 1. Gejl, Ørtenblad, Andersson, Plomgaard, Holmberg, Nielsen (2016). Local depletion of glycogen with supra-maximal exercise in human skeletal muscle fibres. J Physiol 2. Kent, Ørtenblad, Hogan, Poole, Musch (2016). No Muscle is an Island: Integrative Perspectives on Muscle Fatigue. Med Sci Sports Ex. 3. Ørtenblad, Westerblad Nielsen. (2013) Muscle glycogen stores and fatigue (Review). Journal of Physiology 591 (18):4405-4413.

Frequency effects in cross country skiing - biomechanical and physiological aspects

Lindinger Stefan

Cadence during cyclical human activities has been in research focus and the 'optimal cadence' (OC) or effects of forced and freely chosen/favored frequencies were highlighted regarding efficiency, economy and performance (refs Marais/Pelayo, 2003). In cycling the effects of cadence on energy consumption have been widely analyzed, connecting low cadence strategies to higher efficiency, showing top athletes using cadences exceeding most efficient ones, highlighting similar effects of most efficient and freely chosen ones on performance and designating power to be main factor affecting the OC (e.g. Ettema/Lorås, 2009). OC research is partly controversial and related to individual characteristics (anthropometrics, etc.) (Marais/Pelayo, 2003). Bipedal or two-arm driven locomotion showed a U-link of cadence and cost, and freely-chosen and OC concurred and increased with speed/power (refs Leirdal et al., 2013). Of note is that the phenomenon of locomotor-respiratory coupling pattern has been assessed, indicating rather increased variability of frequency coupling resulting in lower oxygen consumption than perfect coupling at preferred walking frequencies (refs O'Halloran et al., 2012). Biomechanical-physiological frequency effects in XCS are hardly examined despite its interesting quadrupedal nature (Leirdal et al. 2013; Lindinger/Holmberg, 2011; Smith et al., 2013). In G3-skating at speeds of 10-13-16-20 km/h at low-free-high frequencies showed an increase of freely-chosen frequency and a gross-efficiency (GE) rise with power, while at the highest speed high frequency caused reductions of efficiency and performance (Leirdal et al.2013). Besides studies on breathing aspects during skating (G2/3/4) (Fabre et al., 2007; Smith et al. 2013), biomechanical-physiological effects of frequencies were assessed using double poling (DP) (40-60-80 cycles·min-1;12-18-24km·h-1) (Lindinger/Holmberg, 2011). Freely-chosen frequencies were close (37-46 cycles·min-1) to the lowest forced frequency. Pole contacts (<200ms) and %-recovery times decreased with frequency whereas leg-joint ranges of motion/min increased, creating great internal work and energy cost by trunk movements in each cycle. High frequencies showed physiological disadvantages with increased oxygen cost, lactates (J-shape) and decreased gross- and breathing-efficiency. Due to the complex nature of XCS techniques further combined biomechanical-physiological studies have to be performed and the locomotor-respiratory coupling must get into focus. REFERENCES: Ettema G, & Lorås H. (2009). Eur J Appl Physiol, 106(1), 1–14. Fabre, N., et al. (2007). Int J Spo Physiol Perform, 2(1), 46. Leirdal, S., et al. (2013). Scand J Med & Sci in Spo, 23(3), 295-302. Lindinger, S. J., & Holmberg, H.-C. (2011). Eur J App Physiol, 111(6), 1103-1119. Marais G, & Pelayo P. (2003). Sports Biomech, 2(1), 103-32. O'Halloran, J., et al., (2012). Eur J App Physiol, 112(3), 929-940. Smith, G. et al. (2013), Abstractbook - ICSS2013, p.40.

Predictors of Instantaneous Performance in Alpine Giant Slalom – How to Best Solve the Permanent Trade-Off between Shortening the Path while Maintaining Speed?

Spörri Jörg , Kröll Josef , Schwameder Hermann , Müller Erich

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INTRODUCTION As stated in the competition rules, alpine ski racing performance is defined as the shortest time from start to finish line. Basically, there are two different ways of performance enhancement: (1) to aim for continuously high instantaneous performance over several consecutive sections; (2) to locally decrease instantaneous performance with the intent of achieving disproportionally higher performance in the subsequent section(s). With respect to the first, minimizing energy dissipation and maintaining high speed has been suggested to be most efficient (Supej et al., 2010). However, this strategy contradicts the theoretical considerations by Lind and Sanders (2004), who suggest shortening the skier's path. Thus, the aim of this study was to assess the relevance of speed- and path-related factors for predicting instantaneous performance in giant slalom (GS). METHODS Six European Cup level athletes participated in a video-based 3D kinematic field experiment. To induce a certain variety of different turn characteristics, the athletes skied on three different pairs of skis varying in sidecut radii (30 m, 35 m, and 40 m). The beginning and end of the turn were defined as the gate passage. For each athlete and ski, two consecutive turns were analysed. On a 26° inclined, water-injected slope, the GS course was set with an average gate distance of 27 m and an offset of 8 m. A 22 point body segment model of the athletes and centre of mass (CoM) was reconstructed in 3D. Instantaneous performance was defined as the time loss per elevation (dt/dz), which depends on the distance travelled per elevation (ds/dz) and speed (Federolf et al., 2012). Speed was further subdivided into entrance velocity (vin) and the rate of energy dissipation per elevation (demech/dz) (Supej et al., 2010). CoM traverse angle was computed in accordance with Spörri et al. (2012). Finally, a multiple regression analysis (stepwise method) was performed and the aforementioned predictors' beta weights were compared. RESULTS A highly significant multiple regression model emerged ($p<.001$, Adjusted R-Square =.912). vin was the most relevant for the prediction of dt/dz turn average (beta weight: -.998; $p<.001$), followed by demech/dz (beta weight: .410; $p<.001$), ds/dz (beta weight: .288; $p<.001$), and CoM traverse angle at the initial gate passage (beta weight: -.185; $p=.002$). DISCUSSION The findings indicate that instantaneous performance is highly dependent on the performance within the previous section (i.e. particularly, on entrance speed and to a lower extent, on the instant direction of motion when passing the gate). Next to these initial boundary conditions, the current study found the strategy of minimizing energy dissipation and maintaining speed to be more important for enhancing instantaneous performance than is shortening the path. Whether these findings are generalizable to situations and athlete levels other than in the current study remains to be verified. CONCLUSION For coaching practice, this study illustrates the importance of also considering an athlete's performance in the sections prior to those of interest, e.g. when interpreting partial video sequences. Moreover, it provides deeper insights into the permanent trade-off between shortening the path and maintaining speed. REFERENCES Federolf et al. (2012). J Sports Sci, 30(10), 1063-8. Lind and Sanders (2004). ISBN 0-387-00722-9. Spörri et al. (2012). Int J Sports Sci Coach, 7(4), 647-59. Supej et al. (2010). Scand J Med Sci Sports, 21(6), 72-81.

Alpine ski racing gate crossing detection using magnetometers

Fasel Benedikt , Spörri Jörg , Kröll Josef , Aminian Kamiar

INTRODUCTION In alpine ski racing performance is defined as total race time. To provide higher time resolution section times can be measured. However, from a performance analysis point of view they might not provide sufficient resolution; it would be preferable to have a time measure at least at each gate. The aim of this project was to propose and validate a gate crossing system allowing to obtain gate-to-gate timing for an entire race. The system should be easy to use and applicable in field without complex setup and analysis. METHODS An inertial measurement unit including a magnetometer sampling at 125Hz was fixed to the lateral side of the right thigh. Strong bar magnets were buried at each gate of the run, causing a distortion in the local magnetic field for close distances to the gates. While skiing down the run, these distortions could cause peaks in the measured magnetic field. Strapdown integration was used to compute the sensor's absolute orientation (Favre et al., 2006). The peaks were detected on the L1 norm of the high pass filtered signal expressed in the global frame. The method was validated on 12 runs of a giant slalom course against high speed video measurement. The cameras (250Hz) were filming the gates number 3 and 16 laterally. The cameras were opto-electronically synchronized with the IMU and three independent raters extracted the gate passing events from the videos. A gate passing was defined as the moment the center of the outside ski boot passed the gate. RESULTS Intra-rater correlation coefficient (ICC 2,1) of video gate passing detection was >0.999 with average maximum rater disagreement of 3.4ms (<1 video frame). All gate crossings were successfully detected with the magnetometer, independent of gate contact. For both left and right turns, the method´s precision (i.e. the error standard deviation) was 9.3ms and 8.3ms, respectively. However, the method´s accuracy (i.e. the mean error) substantially differed between the left and right turn (23.9ms versus 2.6ms). DISCUSSION The proposed method allowed detecting gate crossings fully automatic with a simple setup. It was robust and allowed detecting gate crossing also when no gate contact occurred. The position difference between inside and outside leg led to a time offset during left turns but without compromising the precision, thus still allowing a valid analysis. The offset could be corrected by placing a second magnetometer on the contralateral thigh or attaching a single magnetometer on the sacrum. CONCLUSION The proposed method was both valid and proved highly practical. With very little effort gate-to-gate timings of entire runs can be provided, allowing a more detailed analysis of the athlete's skiing performance. REFERENCES Favre, J., Jolles, B. M., Siegrist, O., & Aminian, K. (2006). Quaternion-based fusion of gyroscopes and accelerometers to improve 3D angle measurement. Electronics Letters, 42(11), 612.

Performance time profiling of elite GS and SL alpine skiers

Spencer Matt , Gilgien Matthias , Haugen Per , Reid Rob

Introduction The difference between winning an alpine ski World Cup race and missing the podium may be a fraction of a second. To date, there is limited information documenting the

performance time profiling of elite alpine skiers. The aim of this study was to provide a detailed analysis of the performance time, ranking in each run, in relation to final placing in the giant slalom (GS) and slalom (SL) disciplines. Methods Official race times and course information for men's and women's GS and SL World Cup competitions for 13 seasons (from 2001) were downloaded from fis-ski.com. In analyses of the top 30 athletes from each race there were 68 to 74 races in total. The place ranking in the 1st run and 2nd runs were documented in relation to the final ranking. Comparisons between GS and SL, sexes and periods of ski equipment/regulation changes (seasons 2001-2006 vs 2007-2012 vs >2013) were analyzed. The following criteria were adopted for interpreting the magnitude of correlation (r) between the measures: <.1, trivial; .1–.3, small; .3–.5, moderate; .5–.7, large; .7–.9, very large; and .9–1.0, almost perfect. Differences between correlations were compared using a Fisher's Z transformation: a default threshold of r = .1 was used as the smallest practically important difference (Hopkins, 2006). Results Ranking in 1st run had a trivially higher correlation with final ranking than for the 2nd run for GS and SL in both women's and men's events. Very large correlations between 1st run ranking and final ranking were observed in both GS and SL for women compared to large correlations for men (mean ± SD; GS women: r = 0.77 ± 0.12; GS men: r = 0.67 ± 0.18; SL women: 0.79 ± 0.12; SL men: 0.68 ± 0.16). Furthermore, on average, the top 3 skiers in the GS 1st run had a final ranking of 2.4 ± 2.8, 3.7 ± 4.0 and 5.0 ± 5.1 (women); and 3.7 ± 6.0, 4.2 ± 5.6 and 5.8 ± 4.7 (men). Whereas the top 3 skiers in the SL 1st run had a final ranking of 1.4 ± 0.8, 3.6 ± 4.1 and 4.0 ± 3.4 (women); and 3.3 ± 5.1, 4.4 ± 5.1 and 6.6 ± 6.8 (men). Only trivial (unclear) differences were evident between periods of ski regulation changes for GS and SL in both women's and men's events. Discussion These data provide a comprehensive analysis of the performance time profiling of World Cup GS and SL skiers. The results emphasis that 1st run performance is highly important for final results in races consisting of two runs. The greater correlations between ranking of 1st and 2nd run to final ranking in GS and SL for women may suggest a greater depth of competition in the men. No meaningful effect of ski regulation changes was evident. This type of analysis may help to understand the effect of start order and equipment regulations on final results. However, many years of data are required for comprehensive analysis. References Hopkins WG. A spreadsheet for combining outcomes from several subject groups (2006). Sportscience., 10:50–53 (sportsci.org/2006/wghcom.htm). Contact: matthew.spencer@nih.no

Variations of the relative age effect within and across groups in elite alpine skiing

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Introduction: The relative age effect has been consistently demonstrated across sports, across sex and age, thus we know a lot about the actual occurrence of the effect (Cobley, Baker, Wattie, and McKenna, 2009). The RAE in alpine skiing have been identified among the youngest level of youth ski racing (Romann & Fuchslocher, 2014) and exists from a national level to an international level (Baker et al., 2014; Müller et al., 2015). However, less is known about the variations in strength of the effect across, and within, skill level. The hypotheses in the present study, were that there would be a general effect of birth month across top level skiers, albeit more pronounced in the speed disciplines (Super-G and downhill) compared to the technical races (giant slalom and slalom) due to a valuable effect of being relatively heavier and taller (Neumayr et al, 2003). Another hypothesis is that skiers with the most World Cup points overall,

are also born in Q1. Method: The top 50 ranked male and female alpine skiers in the World Cup system over the last twenty years (year 1995-2014) were selected. Data were collected from the FIS website (fis-ski.com) and included skiers' birthdates, total World Cup points, and points from each individual discipline (SL, GS, SG, DH and AC). The analysis included both male (n=238) and female skiers (n=235) grouped into either a speed group (DH and SG) or a technical group (SL and GS) based on World Cup points. Chi2-tests were used to assess gender and discipline specific differences in relative age effects, and odds ratios (ORs) and 95% Confidence Intervals (95 % CI) were calculated according to these categorizations. Results: The results show a RAE among the male skiers in the speed disciplines. No significant RAE were found in men specializing in technical disciplines, and none at all in women. Generally, the majority of top level skiers are born in Q1. However, there seem to be a tendency that male skiers with the highest overall score of World Cup points collected over the period are born in Q3 and Q4. Discussion: The finding demonstrates that the RAE can vary across sub-disciplines within alpine skiing at the elite level. The present findings are consistent with previous findings illustrating that alpine skiing require both physical attributes and skills, and that the RAE exists all the way to the elite level. It further suggests that the RAE is largest in sub-disciplines in which physical attributes are especially important (here, the speed disciplines), while being less prominent in those sub disciplines requiring technique (as in the technical disciplines) (Bjerke, Lorås & Pedersen, 2016). The results also show that male skiers with the highest overall score of World Cup points in that period are born late in Q3 and Q4. One explanation may be that these skiers possess a higher degree of motivation and engagement to counteract the RAE existing among younger skiers. References: Baker et al. (2014). Eur J Sports Sci, 14(1), 183-90. Bjerke et al. (2016). Compr Psychol, 5.,1-6. Cobley et al. (2009). Sports Med, 39(3), 235-56 Müller et al. (2015). J Sports Sci Med, 14, 16-22 Neumayr et al. (2003). Int J Sports Med, 24, 571-575. Romann et al. (2014). Int J Sports Sci Coach, 9(2), 347-356.

Mechanical energy and work in treadmill double poling on roller skis

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INTRODUCTION: Recently, it was shown that in double poling (DP) cross-country skiing, body mechanical energy (Eb) fluctuates extensively, thereby demonstrated as an essential characteristic of DP (1). Through active muscle-tendon work (Wmus) in the repositioning phase (RP) Eb is increased. In the following poling phase (PP), parts of this (decreasing) Eb are "directly" transferred to external work (Wext): ~50% of Wext originated from this transfer. However, that study used an ergometer, and some findings did not completely fit with those obtained while treadmill DP on roller skis where e.g. the absolute and relative PP is much shorter (2). In the present study, using the same rationale as in (1), we investigated the fluctuations in Eb, the rate of change in Eb, and external power (Pext) while performing treadmill DP on flat terrain from low to high speeds. We hypothesized that a "direct" transfer of Eb to Wext is a key mechanism of propulsion also in treadmill DP. METHODS: Thirteen male skiers (24±2yrs, 77±7kg, 183±5cm) performed roller skiing DP at LOW, MOD, and HIGH intensities (15, 21 and 27kmh-1) on a 1% inclined treadmill. Motion capture analysis was used to obtain body centre of mass (CoM), Eb, and its time derivative (power, P). Eb and Pb were calculated similarly to (3). Load cells recorded the resultant pole forces (Fp). Pext was calculated as the dot product of the Fp and CoM velocity vectors (the CoM velocity vector being relative to the treadmill belt speed). The sum of Pext and

Pb was defined and interpreted as the rate of Wmus (3). Time integration of P yielded the amount of work done in PP and RP. RESULTS AND DISCUSSION: Mean Wext was 152±19, 223±30, and 290±41 J cycle-1, from LOW to HIGH. Eb fluctuated extensively, and Pb fluctuated out-of-phase with Pext. In the PP, energy was both absorbed and generated by muscle. However, net Wmus was positive and amounted to 70±18, 103±29, and 111±45 J cycle-1 within PP. Thus, ~44, 45, and 37% of Wext was generated by muscle, meaning that ~56, 55 and 63% of Wext originated from a "direct" transfer of Eb. Wmus was 86±14, 123±21 and 180±28 J cycle-1 in the RP, leading to an increase in Eb. This means that ~55-63% of Wmus was done in the RP, an amount similar to as in ergometer DP (1). Both in ergometer and in treadmill DP, considerable Wmus is done in the RP, increasing Eb. By "falling on the poles" in the PP, part of Eb is transferred to Pext. This raises the ability to deliver very high instantaneous power outputs within a short PP. CONCLUSION: Extensive fluctuations in Eb seem to be a characteristic of treadmill DP. Although considerable net positive Wmus is done within the PP, a "direct" transfer of Eb is a key mechanism of propulsion, which is made possible by engaging the legs as a major source of energy generation over the cycle. References: (1) Danielsen et al MedSciSportsExer 2015.47,2586-2594 (2) Pellegrini et al JExpBiol 2014.217,3910-3918 (3) Riddick et al JBiomech 2016.49,436-441

3D Kinematic of lower limbs in freestyle cross country skiing (XCS) technique during WC (Dobbiaco 2012) and WChs (Fiemme 2013)

Canclini Arrigo , Canclini Antonio , Pozzo Renzo , Baroni Guido

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INTRODUCTION: The skating technique has five predominant subtechniques, known as gears (G1-5) as suggested by Nilsson (2004). In the '90s several studies were conducted in attempt to describe the most relevant aspects of XCS freestyle, but the kinematic information is generally limited in the velocity range. More recently Kvamme (2005), Smith (2007), Lindinger (2010), Stöggl (2010), Andersson (2010) compared biomechanical characteristics of the main skating techniques. The purpose of this work was to collect and to analyze the 3D kinematics of the main freestyle XCS gears (G2,G3,G4) performed by elite skiers engaged in recent top races. We focused on the lower limbs posture, and we measured the ski orientation angle and edging angle. Results were compared to the mathematical model proposed by Driessel (2004). METHODS: Data collection was performed in 2012 and 2013 during WC-XCS individual FT races. Dedicated software for video analysis (DLT) was used (Baroni 1998). A total of 11 male skiers (ranking 1-22) were analyzed on 2 sections races (flat and uphill ≈10°) where the athletes performed G3 or G4 (flat-Sprint Qualification), and G2 (uphill-15 km FT). RESULTS: For each subject we present the results showing the ski orientation, edging and knee angle of skiers performing G2, G3 and G4. Specific kinematic parameters were calculated for each athlete which are reported in mean values averaged on 2-3 movement cycles: Terrain/ Gear: 10° uphill (G2) -- Flat(G3) -- Flat(G4) Subjects: N=11(G2) -- N=6(G3) -- N=5(G4) CL (m) (cycle length): 3.60±0.28(G2) -- 7.32±0.32(G3) -- 11.56±0.58(G4) CT (s) (cycle time): 1.12±0.06(G2) -- 0.80±0.06(G3) -- 1.31±0.11(G4) Avg. V (m/s): 3.20±0.28(G2) -- 9.13±0.29(G3) -- 8.78± 023(G4) Time-Poling / CT: 26%±2%(G2) -- 26%±2%(G3) -- 20%±3%(G4) Elbow ang (°) at Pole Plant (PP): 80±14(G2) -- 70±5(G3) -- 73±17(G4) Ski Orient. ang(°) (avg stroke): 29±4(G2) -- 5±2(G3) -- 5±2(G4) Knee ang (°) (begin stroke): 100 ± 15(G2) -- 102 ± 12(G3) -- 110 ± 15(G4) DISCUSSION/CONCLUSION: On the flat terrain, we found out that skiers adopting G3 were faster than those performing G4.

Moreover, we found that the fastest skiers have longer cycle rate (CR): indeed the correlation coefficients between mean velocity and CR are r=0.62 in G3, r=0.66 in G4. In G2 we found a correlation with CL (r=0.62) and Push Time (r=0.69). These results present the same trend of previous studies conducted on diagonal stride on uphill in classical technique (Lindinger 2007, Canclini, Smith 2003). The kinematics patterns of ski orientation, edging and knee angles were found to be quite similar to the literature data (Smith 2003) and exhibit a certain degree of coherence with the mathematical model proposed by Driessel (2004). Moreover, the skiers adopted different strategies to perform the stroke with respect to lower limbs angular variations. REFERENCES Driessel K, Fink P, Hentzel I (2004). The dynamics of ski skating. UMAP Journal Smith G (2003). Biomechanics of cross country skiing XCS. Handbook of Sports Med Science (Rusko)

Comparative 3d kinematic and dynamic analysis of diagonal stride in elite backcountry skiing (SKIALP) and cross country skiers

Pozzo Renzo , Canclini Arrigo , Canclini Antonio , Baroni Guido

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INTRODUCTION: In recent years the backcountry-skiing (SKIALP) has become more and popular and SKIALP skiers improved their technical and physiological performances. Due to the complex multiparametric environment conditions (air and snow temperature, track, tech-niques, gradients, boots, ski) and the relatively recent development of the discipline, there is a lack of specific studies especially under race conditions (Pozzo 2015). On the other hand, technique analysis on elite cross country (XCS) skiers, as well comparing normal race with treadmill conditions have been undertaken (Canclini 2007, Halonen 2015). The purpose of this study is to compare the kinematics and the dynamics patterns of elite SKIALP and XCS skiers under normal competition conditions. METHODS: The data collection was performed in 2015 and 2016 during a test competition. Dedicated software for 3-D video analysis (DLT method) was used. Additionally, force applied by the feet was recorded via Pedar pressure insoles operating at 100 Hz. A total of 12 male skiers of the Italian Ski Team (6 SKIALP, 6 XCS) were analyzed on an uphill section race (30 m, ≈8°) where the athletes performed classical technique at nominal individual race velocity. RESULTS: Mean value averaged on 4 movement cycles were calculated. Significant differences were found in the force acting on the foot plant according to the most relevant contact phases. During gliding, XCS skiers show lower values compared to SKIALP (0,51-0,44 BW vs 0,73-0,71 BW left to right), while, during pushing the opposite was found (1,99-1,93 BW vs 1,62-1,56 BW). Mean velocity, cycle length and knee angle at foot contact were higher for the XCS group. Angles-vs-angles plots were used to investigate individual coordination patterns, which in turn were mostly individual dependent. DISCUSSION/CONCLUSION: The overall performance level of XCS skiers were significant higher with respect to the SKIALP. The relation between force impulses indicates a more efficient technique for XCS skiers, i.e. lower friction during the gliding phases and higher im-pulse during pushing phases. Different kinematics patterns of elbows angle at pole planting seem to correlate with difference in the force applied to the feet especially during the gliding phase. However, the inter-subject variability in SKIALP is greater than in XCS. REFERENCES Pozzo,R (20016). 3-D kinematic and dynamic analysis of diagonal stride in elite skialp. In: Proceedings ICSNS III Canclini,A (2007).3-D biomechanical analysis of the classical technique in ski touring.. In: Proceedings ICSS IV.

A Portable Post-Processed Kinematic GNSS Receiver for Advanced Ski Measurements

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INTRODUCTION Since a kinematic Global Navigation Satellite System (GNSS) has highly accurate positioning ability, it has been used for kinesiology (Gilgien, et al.; 2013; Supej, 2010). Unlike camcorders, GNSS receivers must be attached to the measured subject, mostly attaced on the body of the skier. Therefore, we have developed a compact and lightweight GNSS receiver named AT-H-02 with a post-processed kinematic mode. The purpose of this paper was to validate the positioning accuracy of the AT-H-02 during skiing. Moreover, we tried to estimate the coefficient of friction (COF) by using the AT-H-02. METHODS Portability is highly demanded for GNSS receivers targeting ski and other snow sports. The AT-H-02 with 78x38x18 cubic mm size and 69g weight meets the demand. We found the AT-H-02 to be 7 times smaller and 5 times lighter than another portable GNSS receiver (here: GCX2 by SOKKIA with kinematic mode). Static position analysis of the AT-H-02 results in 1.6mm and 3.0mm RMS errors in horizontal and vertical directions, which are 1/300 of SX Blue II by GENEQ Inc. with differential mode. We performed two experiments to validate the AT-H-02 positioning accuracy. The first was Alpine skiing by a semi-professional instructor at Naeba in Japan. The second was a wax gliding test conducted by a Nordic combined Olympian at Nayoro in Japan. The subjects waxes were 4 different base waxes and 1 fluoro compound wax (Gallium). The coefficient of friction (COF) was calculated based on the law of energy conservation and position data, and then fitted to the Stribeck curve. RESULTS and DISCUSSION From the Alpine skiing experiment at a 694.8m downhill, positioning accuracy was H:7mm and V:24mm RMS. The velocity ranged from 0.0 to 14.0 m/s. We confirmed that the velocity obtained by the AT-H-02 was in good agreement with that by Doppler interferometry. From the wax test experiment at a 10.2 degree angle slope, positioning accuracy was H:14mm and V:21mm RMS. The estimated COF at 1 m/s of the fluoro wax AXF30, and the four base waxes VIOLET, PINK, BLUE, GREEN were 0.0145±0.00029, 0.0149±0.00004, 0.0156±0.00095, 0.0167±0.00055 and 0.0176±0.00037, respectively. The air and the snow temperature at the experimental field were 2.7 and -0.8 degree C, respectively. The snow was new and wet. Since AXF30 and VIOLET are for temperature between -4 and +3 degree C, their COF became smaller than other waxes. Fluorine-added AXF30 is better than VIOLET because the snow was wet and had water content. CONCLUSION We have developed a portable post-processed kinematic GNSS receiver AT-H-02. From experimental results, the system is capable to measure positioning during alpine skiing with a Millimeter order accuracy and also for measuring quite small COF differences among ski waxes. REFERENCES 1) Gilgien M., Spörri J., Chardonnens J., Kröll J. and Müller E. (2013). Determination of External Force in Alpine Skiing Using a Differential Global Navigation Satellite System. Sensors 2013, 13, 9821-9835. 2) Supej M. (2010). 3D measurements of alpine skiing with an inertial sensor motion capture suit and GNSS RTK system. J. Sports Sci. 2010, 28, 759-769.

The use of a smartwatch to analyze the modern interpretation of Marcialonga XC-ski race.

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Introduction Even though tens of thousands cross-country skiers participate every year at different ski marathons, only few scientific works1,2 focus on this type of long-distance races. The difficulty in collecting and analyzing data for long time with the non-invasive devices could be the limitation. Nowadays, smartwatches allow the acquisition of physiological and mechanical (IMU) data in reference to GPS data during race. We used this technology to detect physiological effort and to discriminate the techniques used during the classic long-distance race Marcialonga 2015. Methods Thanks the collaboration of the Marcialonga Organizing Committee 16 participants wear a smartwatch (Wear-IT, Padova, Italy) that collected IMU data, GPS signal and HR frequency during the 42th Marcialonga. A proprietary algorithm (Matlab, The Mathworks, Inc., USA) was used to identify the three classical sub-techniques (diagonal stride (DS), double poling (DP) and double poling with a kick (DPK)). The algorithm has been developed by comparing IMU data and video (GoPro, Woodman Labs, California) collected during the 5 weeks before the race, on a large number of athletes skiing in different condition. Results The total length of the race was reduced by the Marcialonga Organizing Committee from usual 70 to 56 km due to the lack of snow. Only 14 of the athletes involved in the study completed the race with a delay in the finishing-time from the winner between 8'46" and 1h02'46". The athletes performed 17.0±21.3% of the total race time over the 2th threshold and only 8.3±16.1% below the 1th threshold. Most of the race time (69.8±18.8%) was performed between 1th and 2nd threshold. The main technique adopted was DP (72.4±7.1% of the total time), only 4.5±2.7% kick DPK and 0.9±1.0% DS, the remaining time (22.2±6.7%) has been spent without pushing. Due the altitude profile we can divide the race in two homogenous parts, a first part mainly flat and a final climb (first part: DP 69.6±1.2%, DPK 3.3±0.1%, DS 0.5±0.0%, Null 26.6±1.2%; final climb DP 91.4±7.6%, DPK 0.7±1.1% DS 7.9±6.7%). Discussion and conclusions The heart rate data confirm the great effort of this type of race. The most innovative results are the classification of the technique used during the race. The data underline the high use of DP not only in the flatter part of the race but also in the final climb where the athletes chose whether to use DP or DS (before the final climb there is wax service) instead the DPK. DPK is preferred at DS in the first part of the race. The importance of this type of races, considering the large number of competitors, suggests the need of further investigation that are now feasible thanks to the modern smart devices. Bibliography 1. Millet GY Neuromuscular fatigue after a ski skating marathon. Can J Appl Physiol 2003 2. Boccia G Central and peripheral fatigue in knee and elbow extensor muscles after a long-distance cross-country ski race. Scand J Med Sci Sports 2016.

Using a real-time location system to track and analyze performance in cross-country skiing

Swarén Mikael, Stöggl Thomas , Supej Matej , Eriksson Anders

Introduction Previous studies have used numerical simulation models to calculate different pacing strategies in cross-country skiing (XCS). However, none of these studies have used pre-collected real-time locating data, with high sampling frequency, from an actual race. The aims of this study were to 1) validate a real-time location system (RTLS) to track XC skiers and 2) investigate the possibilities to use a power balance model to analyse differences in power output strategies. Method An RTLS consisting of 20 locators was positioned around a XCS sprint course.

For validation purpose, one elite skier, equipped with the rover of a real-time kinematics global navigation satellite system (RTK GNSS) of a centimeter accuracy, performed three laps with different intensities around the track. Three RTLS tags were attached to the RTK GNSS antenna and 50 Hz RTLS and 20 Hz RTK GNSS positioning data were recorded simultaneously. Spline models, based on the RTLS data were constructed and knots for the spline interpolation were taken at 0.5 Hz intervals. RTLS data from the time trial and the big final for one female and one male skier, were used to analyze propulsive power. Instantaneous skiing speeds and distances were calculated by enumerating the spline functions and their time derivatives at time intervals of 1 ms. Propulsive power was estimated by using the power balance model. The skiers were assumed to be in the deep-tuck position at speeds above 10 m/s and the propulsive power produced by skiers was set to zero. Active propulsive power only included the sections where the skiers actively created propulsion. Full race propulsive power also included the sections where the propulsive power was set to zero. Results The mean speeds from the RTK GNSS were 4.1 m/s, 4.7 m/s and 5.2 m/s at low, medium and high skiing intensity, respectively. The mean speeds from the spline calculations were 4.3 m/s, 4.8 m/s and 5.2 m/s. The maximal speeds at the three different intensities were 13.8 m/s, 13.2 m/s and 13.5 m/s vs. 15.9 m/s, 14.5 m/s and 14.5 m/s. for the RTK GNSS and the spline calculations, respectively. The mean full race propulsive power in the time trial and final was 386 W and 311 W for the female and 400 W and 386 W for the male. Mean active propulsive power in the time trial and final was 414 W and 404 W for the female, and 577 and 530 W for the male. Maximum instantaneous power was achieved during steep uphill and was in the time trial and final 939 W vs. 978 W for the female and 1339 W vs. 1153 W for the male. The mean power during the spurt in the time-trail and final was 361 W vs. 380 W and 475 W vs. 411 W for the female and male respectively. Discussion The collected continuous positioning data enable detailed analyses of trajectories and skiing speeds in XCS racing. RTLS data provide precise estimates of the mean skiing speeds but is lacking in accuracy for determination of momentary speeds. Based on spline interpolated RTLS data, the power-balance model provides mean propulsive power in line with previous research. The maximal power output is however higher than previous simulations have assumed. The post-race analysis provides the actual pacing strategies, employed by the skiers during the race. This information allows in-depth analysis regarding pacing, tactics and the physical demands in XCS racing.

Alpine skiing and cardio-metabolic health

Dela Flemming

In the past several decades, there has been a decline in daily physical activity, both at work and in leisure time. The impact of a population doing less and less physically demanding activities, thereby increasing inactivity time, has obvious and well-documented consequences in terms of increase in the incidence of obesity, cardiovascular disease, cancer, and type 2 diabetes. Related to this, but also a feature per se, is the loss of skeletal muscle mass that may follow ageing, i.e. sarcopenia. The etiology of sarcopenia is simple. It is a disuse disease, that may trigger a cascade of vicious circles in which in particular cardio-metabolic diseases develops and thrives. With the increasing number of aged people in the European Union, measures should be taken in order to avoid inactivity related diseases in the aging population and the crucial time-point is some years before the time of retirement. At this time point exercise habits should be established

acknowledging that the physical activity level at the age of 70 is a strong determinant for disability at age 75. It is also well established that increased physical activity improves the lipid profile and blood pressure and has beneficial effects on cardio-metabolic diseases. Furthermore, physical training improves skeletal muscle and adipose tissue insulin sensitivity. Thus, there is a strong inverse relationship between cardiorespiratory fitness and the metabolic syndrome. There is no particular form of exercise or sports activity which is better than the other. The exercise that works best, is the one that is actually being done. Alpine skiing offers an attractive possibility and it is unique in its simultaneous training of both strength and aerobic capacity. Thus this form of sport seems well suited for elderly, otherwise sedentary people who are in need for improvements in both muscle mass/strength and aerobic capacity. Alpine skiing can be used as leisure time activity, but also as a specific rehabilitation approach after surgical procedures. In the lecture, focus will be on metabolic and muscular adaptions to alpine skiing in elderly people with data from clinical intervention studies. In addition to group effects and differences, individual trajectories of metabolism over a six-year period will be discussed.

The effect of jump design on rider kinematics and reaction forces in snowboarding – a methodological study

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INTRODUCTION: The use of terrain parks and jumps has great appeal to freestyle skiers and snowboarders alike. Currently, there are no rules or official guidelines for the construction of such jumps which may in part explain the numbers of fatalities observed in the recent years. Hubbard et al. (2009) suggested to construct the jumps and landing slopes in a way that the effective fall height can be limited to, e.g., 1 m. The construction of the jumps could be controlled by GPS-based technology and applied in any ski field. The purpose of this study was to compare the effects of run-in velocity and landing slope on board reaction forces and rider kinematics in two different terrain park jumps. METHODS: One expert snowboarder was equipped with two dynamometric binding plates to measure forces acting between the binding and snowboard (Kersting et al., 2010). The athlete was wearing a motion capture suit (Xsens, NL) and an additional IMU sensor applied to the board. The jump geometry and trajectory of the rider were surveyed by a RTK GNSS system (Leica, CH) with a reference station at the top of the course and the rover on the athlete's back. The systems were synchronized by a set of jumps. The reference trajectory surveyed by the GNSS system was fused with the body motion capture data. The athlete performed three jumps from three run-in distances across two differently designed snowboard jumps. RESULTS: The method allowed to precisely analyze the segmental motion as well as the full-body motion during all jumps. The dynamometric platforms retrieved all components of the ground reaction forces (GRF) and moments transferred to the binding. Maximum normal force peaks were higher for the designed jump while peak loading was not affected by run-in distance. On the standard jump lower forces were measured in some conditions, while the magnitude was strongly depending on the run-in distance and therefore jump length. The effect on joint loading is currently under analysis. DISCUSSION: The collected kinetic data provide support for the claim that jumps can be designed which keep landing forces constant and low over a whole range of run-in velocities and jump distances. If standard jumps are approached with varying incoming velocities a strong effect on landing forces can be seen. CONCLUSION: The force plate system in combination with IMU-based motion capture and

precise GNSS recordings allows for motion capture during skiing and snowboarding over large capture volumes. The application of this data collection system would allow to validate the effects of designed jumps and estimate the injury potential in other features found in terrain parks. ACKNOWLEDGEMENTS: ISEA Wintercamp 2015, Tognola skiing resort, San Martino di Castrozza, IT. REFERENCES: Hubbard, M. (2009) Journal of the ASTM International. 6 (1): 1-9 Kersting, U.G., McAlpine, P., Kurpiers, N., de Zee, M. (2010) In: Proc. of the 2nd Mtg. of the Ifab, 16 – 18/09/2010, Seattle, WA, USA.

Accurate temperature measurement of interface between ski and snow surface for frictional heating evaluation

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INTRODUCTION: To understand the snow friction and the sliding mechanism of skis, the absolute temperature on interface between ski and snow is required to estimate the ice properties under the frictional condition. Additionally, interface temperature is also required to improve the performance of ski wax. In previous works, Warren et al. (1989) reported the temperature variation during downhill ski by thermocouple. In addition, Schindelwig et al. (2014) measured interface temperature using an infrared temperature sensor. However, these sensors have the difficulties to measure the absolute temperature in principle. Our final goal is to understand the relationship between the friction phenomena and interface temperature. In this work, the objective is to clarify the interface temperature and its variation during sliding by measurement with thermistor. METHOD: A thermistor of 0.5mm in diameter and 2mm in length was used. The thermistors were vertically inserted through the hole bored in the ski and fixed with thermal conductive glue. Four thermistors were installed at the top, near the toe, near the heel and at the tail of ski. In addition, a portable data acquiring system with a 24 bit analog-digital converter was developed. The sampling frequency, accuracy and resolution were 16 Hz, 50mK, less than 0.1mK, respectively. The experiments were conducted in a large cold room in Shinjo Cryospheric Environment Laboratory. The room temperature was set at -10, -5, -2 deg C. The length of the sliding area was 14m. The measurement system consisted of a ski, frame, weight and measurement devices. The measurement system was dragged by the motor with a constant velocity from 0.1 to 3 m/s. RESULTS and DISCUSSION: We successfully measured the interface temperature by the thermistor. When the velocity was 3.0 m/s, the sliding duration was only 3 sec. In this duration, we measured a temperature increment of 0.6 deg C. Additionally, we compared the difference on the frictional heating of waxes (Gallium Extra Base Pink and Violet). The temperature difference between two waxes was 0.3 deg C, hence, a difference of frictional heating was detected. By using accurate temperature data, the temperature effect on the friction type can be evaluated. CONCLUSION: We could measure the interface temperature by using thermistor. It is difficult to measure such a small temperature difference by a conventional thermocouple or infrared temperature sensor. This temperature measurement device can be applied to real field experiments in the future. Additionally, the friction force distribution on the ski might be estimated by measuring temperatures at multiple locations. Schindelwig, K., Hasler, M., Van Putten, J., Rohm, S., & Nachbauer, W. (2014). Temperature Below a Gliding Cross

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Posture optimization of ski jumper for better aerodynamic performance: 1. Experiment

Bang Kyeongtae , Kim Heesu , Kim Jonghyun , Ahn Eunhye , Jung Daehan , Kang Chil-Ku , Kim Hyun-Ki , Choi Heung-Chul , Choi Haecheon

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Introduction: In a ski jumping competition, the flight distance is largely affected by the flight posture of a ski jumper. Several researchers observed flight postures of ski jumpers by using cameras, and investigated the aerodynamic characteristics of ski jumping flight by measuring drag and lift forces on a simplified ski jumper model in a wind tunnel. In most of previous studies, however, only simplified ski jumper models were used and there were a few studies on the variation of aerodynamic forces with ski jumpers' various posture parameters in relation to the aerodynamic performance of a ski jumper. Methods: In the present study, we construct two replication models of ski jumpers by using three-dimensional surface data obtained by scanning the bodies and skis of the Korean national team members. Pelvic and ankle joints are inserted in the models to make various flight postures. We conduct a series of wind tunnel tests, and measure the drag and lift forces on the models with various flight postures by considering four posture parameters (forward leaning angle (β), ski open angle (λ), ski rolling angle (ϕ) and ski spacing (s)). The Reynolds numbers considered are Re = 540,000 – 1,080,000 (based on the length of the jump ski), and the angles of attack are from α = 20° to 40° (defined as the angle between the direction of the free-stream and the jump ski) with increments of 5°. This α range is adopted based on the measurement data of ski jumping flights, and the value of α gradually increases during the flights. Results: We investigate the effect of each posture parameter on the aerodynamic performance. The lift-to-drag ratio of the ski jumper model is enhanced with decreasing forward leaning angle (from β = 35° to 15°), and the lift-to-drag ratio of the ski jumper model is enhanced with moderate ski opening angle (λ = 30°) and ski rolling angle (ϕ = 15°). We derive optimum values of posture parameters for maximum lift-to-drag ratio at each angle of attack by using a response surface method. The lift-to-drag ratio of the ski jumper model is enhanced (up to 15 %) with predicted optimum flight posture. Discussion: Optimal values of the forward leaning angle are almost constant irrespective of the angle of attack. On the other hand, with increasing angle of attack, the optimal ski opening and ski rolling angles increase, and the optimal ski spacing decreases.

Posture optimization of ski jumper for better aerodynamic performance: 2. Simulations

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Introduction: In a ski jumping competition, the flight distance is determined by the posture of a ski jumper which determines the drag and lift forces. In the present study, we perform a large eddy simulation (LES) of flow past a ski jumper during the flight phase, and evaluate the sectional forces on the head, body, arms, legs, and skis. Methods: The ski jumper models are constructed from the 3D scanned models of Korean national team members. The angle of attack of the jump ski is 30° and the Reynolds number based on the length of the jump ski is Re = 540,000. In addition to LES, a simple geometric model is constructed to predict sectional aerodynamic forces, where each part of the ski jumper is modeled as a canonical bluff body such as the sphere, cylinder and flat plate. Results: For the 3D scanned model of a player, the mean drag and lift coefficients obtained from LES are lower by 1.8% and 7.1%, respectively, than those of our own experiment. The mean lift to drag ratio is 1.31. The head, body, arms, legs, and skis have the mean lift to drag ratios of 0.80, 1.67, 1.92, 0.72, and 1.76, respectively. The optimal posture of legs and skis is suggested from a simple geometric model, and it decreases the mean drag force by 5.6% and increases the mean lift force by 3.9% compared to the 3D scanned model, which results in the mean lift to drag ratio of 1.44. Discussion/Conclusion: Since the angle between horizontal plane and the moving direction of a ski jumper approximately varies from 5° to 40° during the flight, the horizontal velocity is more increased as the lift force increases or the drag force decreases. On the other hand, the vertical velocity is more decreased as the drag and lift forces increase. Therefore, the suggested optimal posture would increase the flight distance.

Static and Dynamic Characteristics of Jumping skis

Gim Jinsu , Jeon Joohyeong , Kim Bongju , Jeong Taejoon , Rhee Byungohk

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Introduction Physical characteristics of ski affect the ski performance. Not only geometric but also elastic and dynamic properties are included in the physical characteristics of a ski. Moreover in each stage of ski jumping, various features of jumping ski plate influence stability, speed and controllability. The research on ski properties has been conducted for years. However, most of the research were concentrated to alpine skis. We focuses on distinctive characteristics of jumping skis and quantification method of the characteristics. Methods In order to identify the features of skis, a test bench corresponding to the standard ISO 5902 and 6267 was designed. As static test, spring constant, deformation profile and bending stiffness distribution were measured. The standard ski spring testing procedure ISO 5902 were modified for a jumping ski testing. To measure the bending stiffness distribution of jumping skis, each range between contact points and balance point were divided into 4 segment. As dynamic test, an impact test and a modal analysis were conducted to measure a natural frequency, a modal shape and a damping ratio of each bending mode. Results 1. The forebody spring constant of jumping skis showed more than double the afterbody spring constants. The difference of forebody spring constant, among tested jumping skis, was more than 3 times. 2. The deflection profile of tested skis was similar to deflection of homogeneous beam. 3. The bending stiffness distribution of jumping skis showed asymmetric static characteristics. The variation of bending stiffness of jumping skis along the length was larger than that of alpine skis. 4. In the flight condition, the 1st natural frequencies of jumping skis were under 10 Hz. The 2nd and 3rd natural frequencies were at 25~35 Hz and 70~90 Hz. 5. The forebody of jumping ski had a high damping ratio at low frequency. Discussion and Conclusion Spring constant of skis affected dominantly by the ski-length is not a suitable property to compare the elastic characteristics quantitatively. On the

other hand, bending stiffness distribution is appropriate to represent the elastic characteristics of skis. The forebody of jumping skis would have large damping ratio at a low frequency to attenuate the first mode vibration mainly excited in the take-off stage. These static and dynamic characteristics of jumping skis and its testing methods could help skier choose suitable ski plate. Furthermore, jumping ski characteristics could be used for the design and optimization of jumping skis.

Experimental Investigation of Ice Friction Reduction using Micro-Structures for Jump Ski Plates

Lee Jinkee , Kim Sangmyeong , Kim Dohyung , Kang Hosung

Introduction: In contrast with other ski games, ski jumping doesn't have turning motion and glide on the ramp straightly. Therefore, ski jumping shows the fastest speed and competes for longest flying distance using this speed. To enhance the record, there are so many factors to be considered in designing ski jump plate like weight, area, flexibility, frictional property of base and so on. Base structuring is also one of the factors and every jump skies have macro-size and micro-size structures. Many experiments were conducted from ski industries to find out optimum micro-structures. However, theoretical approach for this problem is still incomplete. In this paper, we conducted the experiments with complete theoretical analysis to introduce the friction reduction using ordered micro-structure fabricated plate. Methods: Groove style ordered micro-structures were built on plate. The ice substrate was made by spraying water with high pressure on chilled glass substrate at -35°C. Friction coefficient measuring equipment following ASTM D1894 standard method (velocity = 150 mm/min) in temperature and humidity control chamber and the dynamic coefficients between ice substrate and ordered micro-structure fabricated plate were measured at low temperature. To figure out the effect of ordered micro-structures, three experimental conditions were changed; gap between the micro-scale ordered structures, proceeding direction of the surfaces and ice temperature. Results: These changes are complexly exert on friction layer and produced diverse results. In the experimental condition, value of coefficient of dynamic friction was below the 0.1. Its relation with ice temperature shows the transition from boundary lubricated friction regime to mixed friction regime. And the surface with longer gap length has the lowest optimal friction coefficient of 0.025. Discussion: To define the mechanism occurred between ice substrate and ordered micro-structured surface, we adopted the concept of the real contact area concentration, squeezing out of the water layer, capillary bridge resistance. From these considerations, we present the modified ice friction model containing the patterning effect and capillary bridge resistance. Finally, it suggests a design to reduce the coefficient of dynamic friction on ice using micro-structure fabricating and contribute to enhancing ski jump record.

Relationship of Mental Skills and Cognitive Performance Parameters within Alpine Skiers, Soccer Players and Martial Artists

Amesberger Günter , Hofer Andreas , Finkenzeller Thomas

INTRODUCTION Purpose of this study is to evaluate the differential power of two questionnaires to discriminate between different sports in adolescent athletes. Further aim is to identify different types of athletes based on mental skills and attitudes in the first step and by adding parameters of executive functioning in the second step. METHODS A sample of adolescent 65 alpine skiers, 78 soccer players and 24 martial artists (M ± SD = 13.81 ± 0.84 years) performed a comprehensive test battery in the setting of an entrance examination to young talent competitive sport schools. The test battery consisted of a questionnaire on mental skills and attitudes in sports (QMSAS) (Finkenzeller, Bernatzky, & Amesberger, 2008) and a scale on excessive effort in sport (Würth & Amesberger, 2007) as well as executive functioning tests. Differences in mental skills and attitudes between sports were calculated by computing 3 (sport) x 2 (sex) MANOVA. Furthermore, two cluster analyses were conducted to identify subgroups in the mental skills domain and to identify patterns including executive functioning and mental skills parameters. RESULTS Preliminary results of the MANOVA demonstrate a significant global effect of sport ($F(2, 270) = 1.45$, $p = .32$, $\eta^2 = .23$) and sex ($F(1, 135) = 1.95$, $p < .01$, $\eta^2 = .28$) in mental skills and attitudes. Concerning sport, a significant effect is obtained for concentration ($p = .03$) and for in hope of success before competition ($p < .05$). Post hoc analyses reveal that alpine skiers assess their concentration significantly lower than soccer players and their hope of success before competition significantly lower than martial artists. Preliminary cluster analyses show the potential of the test battery to filter out different subgroups of athletes. DISCUSSION/CONCLUSION Results confirm the value of the QMSAS to differentiate between different sports in young athletes. Findings on different mental and cognitive patterns in the athletes deliver knowledge on the differential validity that will improve the sport psychological diagnosis. REFERENCES Finkenzeller, T., Bernatzky, P., & Amesberger, G. (2008). Konstruktion und Überprüfung eines Fragebogens zur Erfassung mentaler Kompetenzen und Einstellungen im Sport (FEMKES [Construction and evaluation of a questionnaire on mentals skills and attitudes in sports (QMSAS)]. In G. Sudeck, A. Conzelmann, K. Lehnert, & E. Gerlach (Eds.), Differentielle Sportpsychologie - Sportwissenschaftliche Persönlichkeitsforschung [Differential sport psychology - sport scientific research on personality] (p. 53). Hamburg: Czwalina. Würth, S., & Amesberger, G. (2007). Excessive Effort in Sport - Development and Validation of the Excessive Effort in Sport Scale (EESS). In Y. Theodorakis, M. Goudas, & A. Papaioannou (Eds.), 12th European Congress of Sport Psychology. Sport & Exercise Psychology: Bridges between disciplines & cultures [CD-ROM] (pp. 660-663). Halkidiki: European Federation of Sport Psychology.

Inhibition and Working Memory of Alpine Skiers, Soccer Players and Martial Artists

Finkenzeller Thomas , Hofer Andreas , Amesberger Günter

INTRODUCTION Executive functions are more in more in the focus of sport psychological diagnostics. Findings of previous studies (Vestberg, Gustafson, Maurex, Ingvar, & Petrovic, 2012) were taken up to develop a cognitive performance test battery for the Austrian Network of Sport Psychology (ANSP). Aim of the study is to (1) evaluate differences in executive functioning of adolescent athletes between different sports and to (2) identify cognitive performance patterns in order to gain knowledge of the differential value of the ANSP test battery. METHODS A sample of 65 alpine skiers, 123 soccer players and 24 martial artists (total 212 athletes) aged between 13 and 16 years (M ± SD = 13.78 ± 0.75 years) was administered a comprehensive test battery

in the setting of an entrance examination to young talent competitive sport schools. Cognitive performance was assessed by using a modified version of the Eriksen flanker (EF) task (Eriksen & Eriksen, 1974) and a new developed complex EF task to determine selective inhibition as well as a two back task to record working memory abilities. Differences between sports were calculated by computing 3 (sport) x 2 (sex) multivariate analyses of variances (MANOVA's) for each test. Post hoc tests are reported in the case of global significance. Furthermore, cluster analysis was performed to identify subgroups of similar cognitive performance patterns. RESULTS Preliminary results reveal significant differences between alpine skiers and martial artists in inhibition ($F(2, 206) = 4.00$, $p = .02$, $\eta^2 = .04$) that is indicated by the difference in reaction time between incongruent and congruent stimuli in the EF task. Martial artists show lower differences ($M \pm SD = 33.38 \pm 22.37$ms) than alpine skiers ($M \pm SD = 49.38 \pm 26.17$ms). There is a trend that reaction time on congruent stimuli is lower in alpine skiers compared to martial artists ($p = .08$). Results on the complex EF task support the above described findings. No significant results are obtained for working memory performance between sports. Cluster analysis suggests a three cluster solution. Group 1 consists of athletes who can be described as average in all cognitive performance parameters. Group 2 represents athletes of a high information speed and high working memory ability. In group 3 are athletes having low information processing speed, high inhibition ability and a high error rate in working memory. DISCUSSION/CONCLUSION This study delivers information on the differential power of the ANSP test battery. Further studies should address on the relationship between cognitive performance and athletic performance. REFERENCES Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. Perception & psychophysics, 16(1), 143-149. Vestberg, T., Gustafson, R., Maurex, L., Ingvar, M., & Petrovic, P. (2012). Executive functions predict the success of top-soccer players. PloS one, 7(4), e34731.

The Flow Experience in Alpine Skiing

Brandauer Thomas , Senner Veit

INTRODUCTION: From a psychological perspective, Flow refers to an optimal multidimensional state in which the complete absorption in the task at hand leads to a number of experiential qualities. Alpine skiing is, according to Mihalyi Csikszentmihalyi the "father" of the Flow theory, an ideal Flow-triggering activity (1997). The aim of our presentation is to illustrate to which extent scientific data supports the hypothesis of alpine skiing as an ideal Flow-activity. Four studies with regard to different skiing disciplines will be presented. METHOD: The first study focused on mogul skiing. A questionnaire emphasising single dimensions of the Flow-state was administered to a random sample of 398 skiers immediately after they had skied a mogul-run of easy difficulty, exclusively provided for the purpose of the study. In the second study velocity measurements with a random sample of 112 skiers were carried out on a well groomed slope of medium difficulty with the skiers unaware that they were being measured. Right after skiing down the test-slope they filled in the short version Flow-scale (FKS, Rheinberg, Vollmeyer & Engeser, 2003). In study 3 off-piste skiers (n=33) of different ability evaluated their Flow experience (FKS) after successfully finishing a guided variant run corresponding to their skiing ability. Study 4 had the goal to analyse success and defeat in ski-racing along the lines of the Flow concept. Ski-racers (n=46, FIS to WC-level) were at first asked to think of their best and worst race-runs of the past season to subsequently assess the quality of these runs with the FKS-

scale. RESULTS: Flow occurred in all disciplines. Mogul skiing on an easy bump-piste positively addresses the Flow-facilitating components joy, confidence, sense of control and rhythm. Skiing on a well-prepared slope of medium difficulty can provide intensive Flow-experiences for skiers of all levels as well (FKS-Flow-general score mean=5.57, SD=0.66; ranging from 1 very low to 7 very high Flow intensity). Particularly speed seems to modulate the general Flow score on this type of piste. The faster one skis the higher is the Flow intensity (r=.286, p<.01). Also in off-piste skiing a high level of Flow was reported (mean=5.74, SD=0.71). In line with our expectations an expertise effect was observed. The Flow intensity (mean=6.34, SD=0.66) of experts was significantly higher than the one of lower-intermediate and intermediate skiers (F=10.315, p<.000). In ski-racing significant differences were found between the best and worst runs. In their best races the athletes experienced intensive Flow-states (mean=5.86, SD=0.70), whereas in their worst runs they reported very low Flow scores (mean=3.31, SD=1.14; t=12.873, p<.000). CONCLUSION/DISCUSSION: The presented results back up the hypothesis that, regardless of discipline, alpine skiing can trigger intensive Flow experiences for skiers of all levels. Certain factors seem to modulate the Flow intensity depending on the skiing discipline. Studies that further differentiate Flow facilitative components of certain types of skiing but also investigate the effects of Flow facilitating interventions would be helpful. REFERENCES Csikszentmihalyi. M. (1997). Finding flow: The experience of engagement everyday life. New York: Harper Rheinberg, F., Vollmeyer, R. & Engeser, S. (2003). Die Erfassung des Flow-Erlebens. In J. Stiensmeier-Pelster & F. Rheinberg (Hrsg.). Diagnostik von Motivation und Selbstkonzept (S. 261-279). Göttingen: Hogrefe

Flow and Performance During Race-Like Alpine Giant Slalom Skiing

Bernatzky Patrick , Amesberger Günter , Brandauer Thomas

INTRODUCTION: Flow can be characterised by a high level of concentration and a sense of control but also the occurrence of a merge of action and self-awareness. Jackson and Csikszentmihalyi (1999) postulate a positive relation between flow and maximum performance. However, the relationship of flow and performance in elite sports still is not clarified. Conclusive evidence that flow might lead to enhanced performance is still lacking (Landhäuser & Keller, 2012). With regard to ski-racing scientific data putting the emphasis on the association of flow experiences and performance is sparse. The aim of this study was to examine this relationship in a competitive setting. METHOD: Ten male ski-racers (EC; WC experienced) performed three consecutive giant slalom runs on a standard race-like prepared course with a height difference of 250 meters. A race-like situation was created by handing out start list numbers for each run separately. Time was taken for each run, but contrary to official races the skiers did not receive race time-feedback immediately after each run but for all three runs at the end of the session. Immediately after crossing the finishing line of each run the athletes completed the Flow short scale (FKS, Rheinberg, Vollmeyer & Engeser, 2003) and answered four additional questions referring to the piste- conditions and the quality of their performance. RESULTS: The shortest average race time was accomplished in the first run, with the best piste-conditions. With regard to Flow a medium level was experienced in all three runs, whereas the highest average score was reported for the third run (M=4.00, SD=1.25). A significant correlation between race time and the intensity of the flow experience could be observed in the first run, that is the shorter the race time the higher the flow score (r=-.704, p<.05). Especially the factor (SA) smoothness

of action (SA) was relevant (r=-.702, p<.05). Concerning the relation of Flow and performance the athletes' assessments of their skiing corresponded with the intensity of the Flow experience in all three runs. Making a serious mistake can have a debilitative effect on the general flow-score as was reported for the first and the third run respectively (r=-.702, r=-.740; p<.05). CONCLUSION/DISCUSSION: The findings of the study partly support the hypothesis of an association between the quality of the performance and the flow experience in race-like giant-slalom skiing, even so certain factors have to be considered. Piste-conditions, making serious mistakes but also the fact that for this study the same race-run was repeated three times might have modulated the intensity of the Flow experience but also performance times. Studies that focus on official races and also include different disciplines of ski-racing (downhill, slalom etc.) would be of interest. REFERENCES Jackson, S. A., & Csikszentmihalyi. M., (1999). Flow in sports: The keys to optimal experiences and performances. Champaign, IL: Human Kinetics Landhäuser, A., & Keller, J. (2012). Flow and its affective, cognitive and performance-related consequences. In S. Engeser (Ed.). Advances in Flow research (pp.65-86). New York: Springer Rheinberg, F., Vollmeyer, R., & Engeser, S. (2003). Die Erfassung des Flow-Erlebens. In J. Stiensmeier-Pelster & F. Rheinberg (Hrsg.). Diagnostik von Motivation und Selbstkonzept (S. 261-279). Göttingen: Hogrefe

Constraints led approach improves available time of practice in alpine ski learning

Figueiredo Sérgio , Travassos Bruno , Davids Keith

Introduction Making best use of practice time is directly related to skill acquisition in sport (Davids, Button & Bennett, 2008), due to the demands on effort, access to facilities and expense. To assess how to improve quality of practice in Alpine skiing, we sought to introduce a constraints-led methodology in the practice context, changing traditional coaching approaches by introducing innovative practice task designs that were intended to upgrade the skill acquisition process in the same amount of time. The purpose of this study was to quantify and discuss the introduction of new practice task designs in alpine ski learning to make the most of time spent in training. Methods Ten novice learners where randomly divided into two groups who experienced different learning designs: one group with a traditional approach and the other undergoing a constraints-led learning approach. Both groups arrived at the same skill level to the practice programme. The traditional approach (TA) follows the common ski learning process, using the explanation, demonstration and standard/analytic training exercises as basic resources for the development of the alpine skiing technique. The constraints led learning approach (CLLA) (Davids, et al., 2008) involved tasks designed to establish a progression of challenges and promote the constant adaptations of individuals to changing task constraints, for the development of the alpine skiing basic skills. Specific data were collected with a chronometer to register the different times time used for explaining, practising, and waiting. The percentage of the total time was calculated for each variable in each learning environment. Results Results showed that the constraints-led approach proved to be more effective with regard to time spent in practice (TA=22% and CLLA=41%), which is coherent with the evident diminution of time spent in explanation and demonstration (TA=27% and CLLA=20%) and the time spent waiting for effective practice (TA=51% and CLLA=38%), when compared with the traditional approach. Discussion Although arriving the same level of skiing capacity, these findings helped us conclude that using a constraints-led methodology is valuable in terms of time, effort and expense

compared to traditional approaches which were more costly in all these measures. Conclusion These findings suggest the need to conduct more research comparing constraints-led and traditional learning approaches in adventure sports like Alpine skiing to improve basic skills. References Davids, K., Button, C., & Bennett, S. (2008). Dynamics of skill acquisition: a constraints-led approach. Champaign: Human Kinetics Publishers.

Differences in demonstration of alpine ski school elements

Žvan Milan , Lešnik Blaž , Supej Matej

DIFFERENCES IN DEMONSTRATION OF ALPINE SKI SCHOOL ELEMENTS Milan Žvan, Blaž Lešnik & Matej Supej 1Faculty of Sport, University of Ljubljana, Ljubljana, Slovenia KEY WORDS: alpine skiing, biomechanics, ski school, global navigation satellite system, motor learning INTRODUCTION: In a typical and effective alpine ski school the demands properly escalate through the elements of a ski school. It is often that the elements in a ski school are therefore quite strictly defined in terms of technique as well as execution speed and rhythm. The aim of the present study was to verify the variability of ski school elements time sequences (rhythm) and speed among elite ski instructors. METHOD: Eight ski instructors, members of the Slovenian National Demo team, performed five basic elements of the Slovenian national ski school (Lešnik & Žvan 2010): E1 – wedge curves, E2 – turns with a wedge push-off, E3 – basic swinging, E4 – swinging in a narrow corridor, E5 – swinging in a wide corridor. They were surveyed using a high-end Global Navigation Satellite System (GNSS; Leica 1200 series, Leica Geosystems). Furthermore they were simultaneously recorded with a 50-Hz high definition video camera. For each skier and each element at least 8 turns were recorded. Skiing speed was calculated from GNSS surveyed trajectories and the durations of turn phases were derived from the computer aided video analysis. RESULTS: The speed results demonstrated high differences among subjects in all elements, i.e. in E4 the lowest mean speed was 7.4 m/s and the highest was approximately twice as high. Similarly, the computer-aided video analysis showed substantial differences in the average durations of turns among subjects. In addition, subjects who skied in a higher rhythm in E1, they skied in higher rhythm in E2 and E3 and vice versa. DISCUSSION: The observed differences in demonstration can be clarified by two alternative explanations: 1.) The difference among demonstrators is believed to be excessive and require a thorough intervention and a thorough analysis of the reasons that led to such a result. 2.) Even at the highest level of execution of ski school elements individual perception of choosing an appropriate speed and rhythm played an important role. CONCLUSION: It needs to be reconsidered in the skiing practice how strict definitions in terms of speed and rhythm are necessary in a ski school methodology especially when instructing beginners. REFERENCES: Lešnik, B. & Žvan, M. (2010). A turn to move on: Alpine skiing – Slovenian way, Theory and methodology of alpine skiing. Ljubljana: Faculty of Sport and Ski Instructors Association of Slovenia.

The point of force application during the turn and its meaning for science in skiing

Senner Veit , Mitternacht Jürgen , Hermann Aljoscha , Rauner Kilian , Supej Matej

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INTRODUCTION Ten years ago we have presented a 6-component dynamometer (Kiefmann et al. 2006) which has been designed to measure the loads between the ski and the boot. As the design of this dynamometer not only decouples constraint forces but also realizes an entirely statical bearing concept, it is possible to determine the location, where the vector of the resulting force penetrates the snow surface (point of force application, PFA). In the past different research groups have reported on studies using similar dynamometers (i.e. Lüthi et al., 2005). The focus of these studies was either on top-level skiing (Kupiers et. al, 2009) or they have looked at specific load components (Nakazato et al., 2011). In contrast to these the current submission will take a closer look at the PFA and on the loads present during different manoeuvers during regular, non-competitive skiing. OBJECTIVE There are several reasons why an accurately determined load state and PFA with high time resolution are meaningful for future research and development in skiing. The presentation will illustrate this by giving three examples of our research and interpret the load shift during the turn to better understand the physics of skiing, which cannot sufficiently be explained by the use of insole pressure data. DATABASE April 2014 one male expert skier (50y) former member of Germany's ski instructors demo team performed a total of 17 runs demonstrating (1) short turn, (2) skidded- and (3) carved medium turns, (4) plough turns, (5) skating steps and (6) straight plough. The six-component load state was measured bilaterally using the aforementioned dynamometer. Additionally full-body motion capturing using IMUs (Xsens Technologies, Netherlands) and differential GPS (Leica Geosystems, Switzerland) were recorded. In season 2015 the same manoeuvers (at less perfect realization level) were measured with another eleven subjects using the same set-up. REFERENCES Kiefmann A, Krinninger M, Lindemann U, Senner V, & Spitzenpfeil P (2006). A new Six Component Dynamometer for Measuring Ground Reaction Forces in Alpine Skiing. In E. F. Moritz & S. Haake (Eds.), Volume 2. Engineering of Sport 6 (pp. 87–92). New York: Springer. Lüthi A, Federolf P, Fauve M, Oberhofer K, Rhyner H, Ammann W (2005) Determination of forces in carving using three independent methods. In: Müller E, Bacharach D, Klika R, Lindinger S, Schwameder H, editors. Science and Skiing III. Oxford: Meyer & Meyer Sport; 2005. p. 96-106. Nakazato, K, Scheiber P, & Müller E (2011) A Comparison of Ground Reaction Forces Determined by Portable Force-Plate and Pressure-Insole Systems in Alpine Skiing. Journal of Sports Science and Medicine (10), 754 – 762. Kupiers N, McAlpine P, & Kersting U (2009) Perspectives for Comprehensive Biomechanical Analyses in Mogul Skiing. Research in Sports Medicine 17 (4), 231-244.

IMU and GNSS-based turn switch detection in alpine ski racing

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INTRODUCTION In alpine ski racing, the beginning of a turn can be determined by the crossing point of the athlete's center of mass (CoM) line projected onto the snow surface with the average ski line (Supej et al., 2003). This method was originally dedicated to camera based 3D stereo-photogrammetric systems; however, when using wearable systems (e.g. inertial sensors or differential GNSS) it is not a priori clear how accurate and precise this method performs. Moreover, for wearable systems there might be other reasonable definitions for the beginning of a turn. To this end two inertial sensor based turn switch detection methods were compared to the aforementioned camera system based standard method by Supej et al. (2003). METHODS

Six European-Cup level athletes skied a giant slalom course twice whereas the beginning of one left and one right turn per run were analyzed, resulting in a total of 24 turn switches. For method A the athlete's CoM and ski lines were obtained by fusing inertial sensors (500Hz) fixed to the shanks, thighs, sacrum, sternum, head with a differential GNSS (50Hz), as proposed by (Fasel et al., 2016). The snow surface was estimated by fitting a polynomial surface to the left and right ankle positions. Subsequently, turn switches were detected in accordance to the method of Supej et al. (2003). For method B the turn switches were defined as the crossing points between the lengths of right ankle–CoM and left ankle–CoM vectors computed as in Fasel et al. (2016). Both methods were validated against the camera based reference system (50Hz) and a reference terrain model, as described in an earlier study (Gilgien et al., 2015). RESULTS Mean error (accuracy) and its standard deviation (precision) for method A were 18ms and 21ms, respectively. Method B had an accuracy of 7ms and precision of 38ms. DISCUSSION Both methods could accurately and reliably detect all turn switches. Accuracy for both methods was within time resolution of the reference system (20ms). The decreased precision for method B can be explained by the differences in turn switch definition. CONCLUSION When using inertial sensors the assessed methods provide a valid and simple way for detecting turn switches. For maximum precision a GNSS system should be used in addition. REFERENCES Fasel, B., Spörri, J., Gilgien, M., Boffi, G., Chardonnens, J., Müller, E., & Aminian, K. (2016). Three-Dimensional Body and Centre of Mass Kinematics in Alpine Ski Racing Using Differential GNSS and Inertial Sensors. Remote Sensing, 8(671). Gilgien, M., Spörri, J., Chardonnens, J., Kröll, J., Limpach, P., & Müller, E. (2015). Determination of the centre of mass kinematics in alpine skiing using differential global navigation satellite systems. Journal of Sports Sciences, 33(9), 960–969. Supej, M., Kugovnik, O., & Nemec, B. (2003). Kinematic determination of the beginning of a ski turn. Kinesiologie Slovenica, 9(1), 11–17.

Understanding ski glide test data – acquisition and interpretation

Kirby Richard , Holmberg Hans-Christer , Karlöf Lars

Testing glide properties is an essential component in ski preparation and equipment development as well as the race day selection thereof. All current approaches to glide testing measure something other than ski friction (typically distance or time) and then draw conclusions about ski friction from proxy data. Unfortunately, such data intertwines the frictional forces between the ski and the snow with the force due to wind drag. This combined result is biased by the profile of the test track, which often favors preparations that perform well in certain speed zones or in certain phases of acceleration and deceleration. To fully understand the glide performance of a ski we need to remove the effects of wind drag and bias due to the profile of the test track. Kirby and Karlof (2014) presented a novel system where the velocity evolution along the test hill was measured using optical flow. This was the first time we were able to measure nearly continuous glide performance at sub cm resolution. With such high resolution data, new patterns of glide performance evolved, but the results were still difficult to interpret due to the remaining inability to separate out wind drag from ski-snow friction and because the test track profile favored certain glide characteristics. In the present study, we overcome these issues by re-expressing the high temporal resolution velocity-time data collected with the system described above, into velocity-distance data and acceleration-distance data. This parameterization combined with known slope-distance profile of the test track allows us to

compute the driving force due to gravity at each distance along the test track. Driving force minus mass*acceleration results in the combined resistive forces due to wind drag and snow friction at each point along the test track. Reparameterizing the resistive forces with velocity as the independent variable results in resistive force vs. velocity data. By assuming the wind drag at each speed remains constant between runs (a reasonable assumption with a professional glide tester and no wind), allows us to directly subtract one friction-velocity dataset from another. This cancels out the wind drag force leaving only the difference in force due to ski-snow friction between two pairs of skis being evaluated. Dividing by the normal force results in the relationship between the differential friction coefficient and velocity. We have applied this approach to test data obtained over a range of conditions, present these findings (with statistical confidence intervals) and speculate as to how this novel approach to glide testing might change the manner in which ski preparations are tested and help determine the ideal shape of the test hill, the glide characteristics that are important under different conditions, and the consequences for race strategy and tactics.

Investigations of fundamental processes in ski-snow friction

Lüthi Anton , Fauve Mathieu , Rhyner Hansueli , Müller Erich

INTRODUCTION: Ski-snow friction is a highly dynamic, complex process [1,2]. The aim of the current work was to build up a thorough understanding of the basic underlying processes in ski-snow friction and to use this knowledge to optimize ski base structures in function of snow properties. The investigations were focused on the formation of contacts and the lubricating water between ski and snow. METHOD: Friction tests have been conducted on both structured ice and snow in a cold chamber under well-defined environmental conditions using both a linear friction tester and a circular, 1.6 m wide tribometer allowing tests at various speeds. The snow surface before and after sliding over it has been characterized using high-resolution computed tomography (CT). Tests were done with ski base samples having various base structures. The ski base structures were characterized by 3D surface topography. The laboratory tests were completed by field tests with differently ground skis. The formation of water between ski and snow was investigated using high-speed cameras and light diffraction. A numerical model that simulates heat diffusion into snow and ski and the melting (phase change) at the contact points between ski and snow was build up. RESULTS + DISCUSSION: For hard, well compacted race snow the contact formation between ski and snow is largely determined by plastic deformations in the first layer of snow grains. The contacts between ski and snow cover only a few percent of the apparent ski surface and can be influenced by the ski base structure. Strong experimental evidence for the formation of lubricating water at the contacts was found. The thickness of the water at the contacts lies in the range of 0.01 – 3 micro-meter. Too high formation of water leads to higher friction by increasing the contact surface. CONCLUSION: Friction losses in skiing largely depend on the size and extension of the contacts built up between ski and snow. To reduce friction ski bases should hence be structured in such a way as to minimize the contact surface. In this context, the penetration of the ski into the snow surface should be kept as low as possible. REFERENCES Colbeck S.C. (1992). A review of the processes that control snow friction. CRREL Report Moldestad D.A. (1999) Some Aspects of Ski Base Sliding Friction and Ski Base Structure. PhD Thesis

Considerations and challenges of biomechanical performance diagnostics in ski-jumping

Schwameder Hermann

INTRODUCTION: Biomechanical performance diagnostics in ski-jumping is associated with specific challenges and requests related considerations. The first part of the presentation will provide and discuss some general perspectives of these aspects. The second part presents the evaluation of a portable measurement device to detect ground reaction forces in two dimensions in ski-jumping, which is the main focus of this abstract. To analyze ground reaction forces during ski-jumping take-off, force plates under the in-run tracks and pressure insoles have been used. Their advantages and disadvantages have been widely discussed (Schwameder, et al., 2001). Recently a portable measurement device has been developed (JH Skijump Force Measuring System). This system consists of two separated force plates (fore and rear part) for each ski, and can measure forces in vertical and horizontal direction. It can be mounted between ski and binding without severely influencing the performance of the jumper. The purpose of this study was to evaluate the accuracy of this system in a laboratory setting and to test the device in a field setting. METHODS: The measurement device is based on strain gauges. Calibration factors for the single measurement parts were determined by using a calibrated load cell. In a laboratory setting, the measurement values of the system were compared to measurement values of AMTI force plates in a static (in-run position) and dynamic (squat-jump) situation. After the laboratory measurements the system was tested during actual hill jumps by one participant on a HS 62. For take-off detection a small trigger was attached to the system, which is activated by a small brush, mounted on the take-off table. RESULTS: Linearity was ≥ 99% for all parts of the system during calibration. Differences between the system and the AMTI force plates concerning measured bodyweight during in-run position were <3%. With regard to the squat-jumps, the measurement system underesti-mated the peak forces by <2%, compared to the AMTI values. Jump height was overestimat-ed by <5%. Results from the hill jumps showed plausible data over the entire jumping se-quence and were comparable to former reported values (especially take-off forces). DISCUSSION: The presented measurement device showed high accuracy compared to the AMTI force plates and did not influence the jumpers severely during hill jumps. Therefore it can be concluded that this portable device enables field measurements with a high degree of validity and reliability. The JH Skijump Force Measuring System and its special features can lead to an even better understanding of ski-jumping in general and of the take-off in particular. Schwameder and Müller. (2001). Biomechanics in ski-jumping: A review European Journal of Sport Science (Vol. 1, pp. 1-16).

The development of potentional performance in ski-jumping from the morphological and motoric aspect

Jost Bojan , Ulaga Maja , Vodičar Janez

INTRODUCTION: In the past, several expert systems were designed to evaluate the reduced potential performance model for ski-jumpers. The studies aimed at monitoring the reduced potential performance model of ski-jumpers focused primarily on the motor and morphological variables, which were consistently used in the mentioned model (Jost, Čoh, Čuk & Vodičar, 2015). METHODS: The sample of most talented Slovenian ski-jumpers older than 10 years (n = 150) were constantly tested for morphological and motoric factors in each year in the last twenty years. With the standard expert system "Sports Manager" the state of general longitudinal development of the reduced potential competitive performance (RPCP), depending on their age, was determined. RESULTS: Morphological development of ski-Jumpers is fairly rapid and the athletes can achieve an excellent score of the reduced potential competitive performance already between 14 and 17 year of age. At 17 years of age the RPTU score in the primary motoric area generally is still quite low. The highest peak in development of motoric skills is generally achieved at the end of the youth age category at age 19. In general, the motoric developmental curve may increase for individuals up to 25 years of age slightly. DISCUSSION: Slovenia's greatest achievements in ski-jumping came from athletes under 20 years of age (Primož Ulaga, Slovenia's first World Cup win, Franci Petek, large hill World Champion, Primož Peterka, two-time World Cup Overall winner, Rok Benkovič, small hill World Champion). A special place in the group of talented young Slovenian ski-jumpers is taken by Peter Prevc, who demonstrated elite competitive performance in his first season among senior men when he was only 21 years old. The knowledge of reduced potential competitive performance of young athletes can be used to ensure continuous learning and improvement of the theory and methodology of ski-jumping practice. The only way to obtain this knowledge is through long-term monitoring of the actual and potential competitive performance of young athletes. However, the issue to be addressed in the monitoring process is linked to considerable differences in the scores for various age groups of athletes regardless of their age and sex. CONCLUSIONS: The state of factors of the reduced potential competitive performance model constantly and dynamically varies in time and space, and therefore it is necessary to continuously determine its validity. Between the actual and potential competition performance of ski-jumpers will probably never be possible to determine the magnitude of functional connectivity, which is always present. Due to the presence of many random, unpredictable, unknown and variable factors the validity of the potential performance model will be increasingly dependent on stochastic relationships and connections. Coaching high level competitors in ski-jumping is focused more and more on the development of special motor skills focusing on their optimal development of the morphological and basic motoric factors. REFERENCES: Jost, B., Čoh, M., Čuk, I. & Vodičar, J. (2015). Expert modeling of Athlete sport performance Systems. Hamburg: Verlag Dr. Kovač.

Computation of ground reaction forces in ski jumping imitation jumps based on inverse dynamics

Fritz Julian , Kröll Josef , Lindorfer Julia , Schwameder Hermann

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INTRODUCTION: Ski jumping take-off is considered to be one of the most important phases for a successful jump. Performance diagnostics on this phase during hill jumps come along with high organizational demands and are therefore rarely executed. In order to evaluate the jumpers take-off abilities, imitation jumps can serve as an alternative to hill jumps (Müller, et al., 2000, Pauli, et al., 2016, Schwameder, 2012). Force plates have mainly been used for performance

evaluation, but they are very expensive, can often be used just stationary and cannot collect body kinematics. Therefore, it is aimed to develop a video based performance diagnostics tool, which is: (1) applicable for several imitation jump types, (2) able to collect kinematic and kinetic data, (3) highly practicable. The first step in this project and the aim of this study was to evaluate the accuracy of computed vertical ground reaction forces (vGRF) and derived performance parameters (mean force, mean velocity, jump height, mean power) by using kinematic data in an inverse dynamics approach. METHODS: Ski jumpers performed imitation jumps on a force plate (AMTI, 250 Hz). Kinematic data were collected using 12 Vicon cameras (250 Hz), a full body marker set and an optimization algorithm (visual 3d) to determine the center of gravity (CG) of the jumpers' single segments (14 segment model). Segment mass and vertical acceleration of the CGs served as input parameters for the inverse dynamic model to compute the vGRF during the imitation jumps. The evaluation was conducted by comparing measured and computed force data. RESULTS: In this abstract results from only one jump are shown. Qualitative analysis showed high accuracy between measured and computed force-time curves. Measured and computed mean force was both 1998 N. Computed mean center of mass velocity was 0.01 m/s higher than the measured one (deviation=0.8%). Computed jump height exceeded the measured value by 3% (32.5 cm vs 31.6 cm). Computed mean relative power was 2.03 W/BW and measured mean relative power 2.01 W/BW, which is a relative difference of 1.1%. DISCUSSION AND CONCLUSION: Preliminary results show high accuracy in computation of vGRF and derived performance parameters during imitation jumps using kinematic data in an inverse dynamics approach. The possibility to collect kinematic and kinetic data (2) with just one measurement system would have great implications on practicability (3) and on other areas of application (1). A full body marker set, as used in this study, is not feasible in practice. Therefore, it is necessary to evaluate whether forces could be computed on a sufficient accuracy level, if the kinematic data acquisition will be more simplified (video). REFRENCES: Müller, Benko, Raschner and Schwameder. (2000). Specific fitness training and testing in competitive sports Med Sci Sports Exerc (Vol. 32, pp. 216-220). Pauli, Keller, Ammann, Hübner, Lindorfer, Taylor and Lorenzetti. (2016). Kinematics and Kinetics of Squats, Drop Jumps and Imitation Jumps of Ski Jumpers Journal of Strength and Conditioning Research (Vol. 30, pp. 643). Schwameder. (2012). Challenges and issues in ski jumping biomechanics Science and Skiing V (Vol. 5).

Relationship of squat jumps, imitation jumps and hill jumps in ski jumping from a biomechanical perspective

Lorenzetti Silvio , Windmüller Sabrina , Häberle Ramona , Müller Sören , Ammann Fabian , Schödler Berni , Hübner Klaus

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As hill jumps are very time consuming, ski jump coaches and athletes often perform various imitation jumps and strength exercises for the lower extremities during training sessions. In order to ensure the best possible transfer to hill jumps and thus be most effective, the performed jumps and exercises should be kinetically and kinematically similar to hill jumps (Schmidt & Lee, 1988). Correlations between different parameters of imitation exercises and hill jump performance have been found (Fritz, Lindinger, & Schwameder, 2015; Pauli et al., 2016), however, a direct comparison of the same kinetic and kinematic parameters between hill jumps and various imitation jumps has yet to be investigated. Therefore, this study aimed to correlate common kinetic and kinematic parameters during hill jumps, squat jumps and various imitation

jumps with a catch of the coach. In addition, the root-mean-square errors were calculated. Force and video data of the take-off of 10 Swiss and German athletes were measured during hill jumps (HS106, Oberstdorf Ger), squat jumps (wearing indoor shoes) and imitation jumps performed under six different conditions (rolling 4°, rolling flat, static; wearing jumping equipment or indoor shoes) on a custom build instrumented vehicle. A total of 11 kinetic and kinematic parameters (maximal normal force, maximal momentum, maximal normal take-off velocity, maximal power, maximal force loading rate, take-off time, force ratio of the right and the left foot, knee varus/valgus index, lower body angle, upper body angle, knee joint angle) were evaluated. Non-hill jumps were then ranked in order to identify the jump condition that is most similar to hill jumps. The results show that the main difference between hill jumps and imitation and squat jumps is the higher maximal force loading rate during hill jumps due to the aerodynamic lift. Hill jumps resulted in the highest force ratio of the right and the left foot as well as the knee varus/valgus index, suggesting that these jumps required the highest coordinative skills. Imitation jumps performed on a rolling platform, either on flat ground or on a slope, with indoor shoes were most similar to hill jumps in terms of the force-time and leg joint kinematic properties whereas static imitation jumps and those performed wearing jumping equipment correlated poorly in terms of joint angle kinematics. Thus, non-hill jumps with a technical focus should be performed from a rolling platform and without jumping equipment. Furthermore, high normal force loading rates and the inter-limb coordinative skills should be in the main focus of training. References Fritz, J., Lindinger, S. J., & Schwameder, H. (2015). Correlation between strength related parameters and ski-jumping performance in junior ski-jumpers. Paper presented at the 3rd International Congress on Science and Nordic Skiing, Vuokatti Finland. Pauli, C. A., Keller, M., Ammann, F., Hubner, K., Lindorfer, J., Taylor, W. R., & Lorenzetti, S. (2016). Kinematics and Kinetics of Squats, Drop Jumps and Imitation Jumps of Ski Jumpers. J Strength Cond Res, 30(3), 643-652. doi: 10.1519/JSC.0000000000001166 Schmidt, R. A., & Lee, T. (1988). Motor control and learning (Fifth ed.): Human kinetics.

Tensiomyography as a method for preventing injuries at alpine skiers

Paravlić Armin , Marušič Uroš , Šimunič Boštjan , Lešnik Blaž , Pišot Rado

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INTRODUCTION: Alpine skiing is characterized by high-intensity 90-120 s exercise, which requires repeated high-force isometric and eccentric contractions (Ferguson, 2010). During skiing, due to fatigue, muscles experience changes at biomechanical, biochemical, systemic, and structural levels, that compromise skiing performance and lead to possible ski injuries. There is an increasing number of ski injuries due to rapid skiing equipment change and constant development of skiing technique, in parallel with sedentary lifestyle and low level of functional capabilities of skiers. Studies investigating muscle fatigue usually monitor changes at metabolic or electrical excitation level, while studies monitoring mechanical response are rare. So far, tensiomyography (TMG), as a non-invasive and selective method of neuromuscular assessment, has been used to measure muscle contractile properties (MCP) and was found to a useful tool in detecting muscle fatigue eg. delayed onset of muscle soreness - DOMS (Hunter, et al., 2012). Therefore, we aimed to evaluate MCP of vastus lateralis, vastus medialis and biceps femoris before, during and after 3 days of ski practice. OBJECTIVE: Aim of this study was to detect MCP before, during and after 3 days of ski exercise in sport studies students using TMG. METHODS: We analyzed MCP in 16 sport studies students who were divided, regarding to skiing knowledge,

into four groups (S1 - beginners, S2, S3 and S4-experts). Furthermore, using TMG we detected several MCP (maximal displacement- Dm, contraction time- Tc, sustain time- Ts, delay time- Td, and half-relaxation time- Tr) of three skeletal muscles (vastus medialis- VM, vastus lateralis- VL and biceps femoris- BF). RESULTS: Following three consecutive days of skiing we found that Dm values decreased by 15% (p=0,004) and 10 % (p=0,008) in both VL and VM muscles, respectively, but not in BF. Tc values increased by 4 % (p=0,044) only in VM. In addition, there were no differences between groups in MCP data in considered time. CONCLUSION: Our findings suggest MCP changes during skiing days in students, but changes were muscle specific. TMG changes follows muscle fatigue patters also found in a DOMS study of Hunter et al. (2012). Dm decreased due to increased muscle tone, also confirmed with several validation studies (Pišot et al., 2008; Šimunič et al., 2008; Križaj et al., 2007). Tc increased only in VM muscle, clearly demonstrating that VM is the one of the most important muscles during skiing. Tc increase could be explained due to selective (type II) muscle fiber peripheral fatigue. Interesting the same pattern was observed in experienced and less experienced skiers. Method's reliability, sensitivity, selectivity and non-invasiveness positions TMG as an useful and simple to use tool for measuring muscle contractile properties in a longitudinal designs to detect muscle responses that could have a major determinants of performance and/or health (injuries). REFERENCES: Ferguson, RA. Exp Physiol, 95(3), 404-410. Hunter AM, Galloway SD, Smith IJ, Tallent J, Ditroilo M, Fairweather MM, & Howatson G. J Electromyogr Kinesiol, 22(3), 334-341. Pišot R, Narici MV, Šimunič B, De Boer M, Seynnes O, Jurdana M, ... & Mekjavić, IB. Eur J Appl Physiol, 104(2), 409-414. Krizaj D, Grabljevec K, & Simunic B. MEDICON 2007, (pp. 393-396). Šimunič B, Rittweger J, Cankar G, Jurdana M, Volmut T, Šetina T, …& Pišot R. Zdr Varst, 47 (2), 60-71. Rittweger J, Simunic B, Bilancio G, De Santo NG, Cirillo M, Biolo G, ... & Narici, M. Bone, 44(4), 612-618.

Energy contributions and pacing strategies of elite cross-country skiers during sprint skiing

Andersson Erik

E. Andersson1, H-C. Holmberg1,2, N. Ørtenblad1,3, and G. Björklund1 1Department of Health Sciences, Swedish Winter Sports Research Centre, Mid Sweden University, Östersund, Sweden, 2Swedish Olympic Committee, Stockholm, Sweden, 3Department of Sports Science and Clinical Biomechanics, SDU Muscle Research Cluster, University of Southern Denmark, Odense, Denmark INTRODUCTION: At present, knowledge regarding energy contributions and pacing strategies during successive sprint time-trials (STTs) in cross-country (XC) skiing is limited and, therefore, the current study was designed to examine these parameters. The results shown have recently been published elsewhere (Andersson et al., 2016). METHODS: Ten well-trained male XC skiers performed four self-paced 1300-m STTs on a treadmill, separated by 45 min of recovery. The simulated STT course was divided into three flat (1°) sections (S1, S3 and S5) involving the double poling (DP) sub-technique interspersed with two uphill (7°) sections (S2 and S4) involving the diagonal stride (DS) sub-technique. Treadmill velocity and VO2 were monitored continuously and technique-specific gross efficiency (based on submaximal pre-tests) was used to estimate anaerobic energy production. RESULTS & DISCUSSION: The average STT performance time was 229 ± 9 s and the aerobic energy contribution was 82 ± 5%. A positive pacing strategy was used during all STTs, with 3-9% more time spent on the second half of the course ($P < 0.05$). In addition, the pacing strategy was regulated to the terrain, with substantially higher (~30%) metabolic rates, due to primarily higher anaerobic energy production, for uphill

compared with flat skiing (P < 0.05). The individually fastest STT was more aggressively paced compared to the slowest STT (P < 0.05), which resulted in a higher O2 deficit rate (13 ± 4 versus 11 ± 4 mL/kg/min, P < 0.05), while the VO2 was similar (both 52 ± 3 mL/kg/min). These findings emphasise the importance of a fast start. The within-athlete coefficient of variation (CV) in performance time, VO2 and O2 deficit were 1.3 ± 0.4%, 1.4 ± 0.9% and 11.2 ± 4.9%, respectively, with the CV in O2 deficit explaining 69% of the CV in performance. The pacing strategies were highly consistent, with an average CV in speed of 3.4%. CONCLUSION: The fastest STT was characterized by more aggressive pacing and a greater anaerobic energy production. Although the individual performance time during the four STTs was highly consistent, the small within-athlete variability in performance was related to variations in anaerobic energy production. REFERENCES Andersson E., Holmberg H. C., Ørtenblad N. & Björklund G. 2016. Metabolic Responses and Pacing Strategies during Successive Sprint Skiing Time Trials. Med Sci Sports Exerc. Epub ahead of print.

Do cross-country skiing competitions demand the same from male and female skiers, and what is the importance of the upper body on the gender differences?

Hegge Ann Magdalen

Gender differences in cross-country skiing increase with increasing contribution from the upper body. This raises the question to which extent these gender differences are attributable to the trunk and arms. In order to examine this question, a group of national-class male and female skiers completed a maximal performance test performing a whole-body (WP), upper-body (UP) and arm poling (AP) exercise on an ergometer. The results showed that the gender differences in power output increased significantly from 87 to 97 to 103% during WP, UP and AP, respectively. Part of these gender differences could be explained by differences in upper-body strength, upper-body muscle mass and upper-body training. Furthermore, it was observed that female skiers use the double poling technique less frequently during trainings and competitions than their male counterparts. From these results it may be concluded that female skiers competing at a national level would profit from incorporating higher volumes of upper-body strength and endurance training into their training regime. During an individual time-trial on snow in both the classical and skating style, the greatest gender differences among world-class skiers were found when skiing uphill in both skiing styles. However, the gender differences on the flat sections were significantly greater during the classical than the skating race, which could be explained by the fact that gender differences are greater in double poling than in other skiing techniques. Therefore, also the gender differences at world-class level may largely be explained by the gap in double-poling performance. Following the double-poling differences between genders, it was questioned whether double-poling also was a discriminating factor within the female gender. This was examined by comparing the best female skiers in the world to female skiers of a lower rank during a maximal performance test on a treadmill using the double-poling and diagonal technique. It was found that the differences between world-class and national-class female skiers were not different between double-poling (7%) and diagonal skiing performance (6%). Rather, a general high aerobic capacity (>70 ml kg-1 min-1) and high volumes of endurance training (>400 h in the six months before the season) seem to be of importance to win international races in the women's competition. Hence, these data provide benchmark values for female skiers aiming for medals.

Can altitude training be recommended for elite athletes

Lundby Carsten

Altitude training may be used by elite endurance athletes such as cross country skiers in an attempt to boost exercise performance for competitions held at sea level and at altitude. While there is little doubt that altitude acclimatization (incl. live high – train high altitude training) and perhaps also some "live low – train high" altitude training strategies may increase exercise performance at altitude, the scientific evidence for improvements in sea level performance following any of the various altitude training approaches is less convincing. Thus, "live low – train high" was initially suggested effective and endorsed by many athletes but more recent studies applying double blinded and placebo controlled study designs have not been able to confirm these initial studies. In a similar manner the "repeated sprints in hypoxia" training modality initially showed great potentials to boost exercise performance, but more recent studies – often conducted in a more controlled manner – have not been able to confirm the early findings. During the presentation focus will be given to a recently conducted 4 week long controlled LHTL (2167 m; 17h/day) study in elite cross country skiers, and also newly collected data from a 8 week long (3 sessions/week) "repeated sprint in hypoxia" study will be presented. Both studies had no single parameter of exercise performance increase more in the hypoxia groups as compared to the normoxic control groups.

Why do the best cross-country skiers perform so many hours of low-intensity training?

Sandbakk Øyvind

Endurance training has always been the major component of an elite cross-country skier's training. The 750-950 hours of yearly training among the best skiers include around 80% at low-intensity, with the remaining training done as moderate- and high-intensity endurance, as well as strength, speed and mobility training. Endurance training is performed with skiing, roller skiing and running with and without poles on varying terrain as the predominant modes of exercise. While the high-intensity training is mainly ski specific, skiers vary their mode of low-intensity training considerably. It has been proposed that high amounts of low-intensity training constitute an important preparatory foundation for the more intense competition period in cross-country skiing. The variation between sport-specific training and cross-training during such training help cross-country skiers to tolerate large amounts of training, in combination with a low risk of injury. Low-intensity training has been proposed to enhance general aerobic capacity and exercise efficiency, as well as to improve the tolerance for performing high training loads by facilitating more rapid recovery. In addition, cross-country skiing is regarded a motoric Eldorado, with all its sub-techniques performed in different terrains and external conditions. We know that motor skills need many hours of practice in the specific environment and low-intensity training allows for technical mastery at an acceptable level of stress. However, these positive effects of low-intensity training are mainly based on coaches' practical experiences combined with retrospective analysis of training data, whereas prospective experimental designs on elite endurance athletes are almost entirely lacking the scientific literature. The positive effects of high-intensity training on endurance performance have been shown repeatedly, and the best

athletes' focus on large amounts of low-intensity training do not bring the importance of high-intensity training into question. However, it can be speculated that many highly trained athletes rather should focus on improving the quality of each high-intensity session (i.e., optimization of physical, technical, and mental aspects) than further increasing the number of such sessions. Furthermore, the period of preparation with high loads of low-intensity training is followed by the competition season, during which high-intensity sessions and competitions are more strongly emphasized. It might be that such a progressive increase in the intensity of training over the year is beneficial for the long-term development of elite endurance athletes. For example, the interplay between low-intensity, long-duration training might be complementary to high-intensity sessions in terms of optimizing adaptive signalling

Considerations on the Cost of Transport in Cross-Country Skiing

Herzog Walter , Onasch Franziska , Boldt Kevin , Killick Anthony

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Introduction: Success in cross-country skiing requires a great capacity to utilize oxygen at a high rate. Decreasing the amount of oxygen required for a given speed of skiing is therefore an invaluable advantage. The purpose of this study was to determine oxygen saving strategies in cross-country skiing Methods: We performed three separate studies with nationally ranked skiers (n = 18) to explore strategies for reducing oxygen uptake when skiing at a given speed on a motor driven treadmill using roller skis. First, we studied the oxygen cost of 1- vs 2-skate skiing for speeds from 6-36km/h, second we determined the oxygen cost for entrained and non-entrained breathing while skate skiing just below the anaerobic threshold, and third, we measured the oxygen cost when double poling with poles of different lengths Results: Oxygen requirements are lower for 2-skate than 1-skate skiing on a flat treadmill for speeds up to about 12km/h and for speeds above about 24km/h, but are higher for speeds from about 12-24km/h. When skating with an entrained compared to a non-entrained breathing pattern, oxygen requirements are reduced on average by 4%. Finally, within the rules of cross-country skiing regarding pole lengths, the longest possible poles (close to body height) are best in terms of reducing oxygen requirements when double poling at a speed just below the anaerobic threshold. Discussion: Although oxygen uptake capacity and reducing oxygen requirements are important for successful performance in cross-country skiing, they are not the only factors affecting elite skiing performance. However, we showed with examples of different poling techniques, different breathing patterns, and thoughtful selection of pole length, that oxygen requirements can be reduced for a given speed and slope of skiing by about 5%. Not all of our skiers skied with the technique, the breathing patterns, or the poles that minimize oxygen consumption for a given ski performance, illustrating that other factors might be important in the selection of these variables. However, if minimizing oxygen consumption for a given task was of primary interest, it appears that reductions in the oxygen requirements of 5% can be easily achieved in Canadian national and provincial level skiers. Conclusion: We conclude from the results of our studies that oxygen requirement for a given skiing performance can be manipulated by the choice of the proper skating technique, the synchrony of breathing with the poling cycle, and the appropriate choice of pole length. Boldt, K., Killick, A., Herzog, W. (2016) Quadrupedal locomotion-respiration entrainment and metabolic economy in cross-country skiers. Journal of Applied Biomechanics 32(1) 1-6. Herzog, W., Killick, A., Boldt, K. (2015)

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Exercise Intensity and Pacing Strategy of Cross-Country Skiers during a Simulated 10-km Skating Race

Thomassen Tor Oskar , Formenti D. , Rossi A. , Calogiuri G. , Scurati R. , Weydahl A.

INTRODUCTION: The main goal of the racers during a competition is to regulate their velocity in the most strategically efficient way, in order to finish the race in shortest possible time (Joseph et al., 2008; St Clair Gibson, Schabort, & Noakes, 2001). This distribution of work has been called "pacing strategy" (Abbiss & Laursen, 2008; Foster et al., 2004). Thus, the aim of this study was to observe the cardiovascular demands by monitoring the heart rate (HR) and the pacing strategy by evaluating the speed during a 10-km cross-country skiing race. METHODS: The study was conducted over a 2-week period (March-April 2013) at the end of the Norwegian cross-country skiing season. Eleven young male cross-country skiers (16.45±1.67 yrs; 21.32±2.03 kg/m2) participated. They were all active competitors in regional and national races, and were recruited from local ski teams. An incremental laboratory running test on a treadmill was performed one week before the race to characterize the athlete's aerobic power (VO2 max) and to establish their reference heart rate (HRmax) to define the exercise intensity zones. The 10-km skiing race consisted of 9756m in freestyle (skating technique), divided into four identical laps (2439 m each). The start interval was 1 min. The HR was recorded at 5-s intervals using a heart rate monitor for each subject (Polar Team 2 Telemetry System, Polar Electro Oy, Kempele, Finland). RESULTS AND DISCUSSION: On average, the skiers completed the 10-km race in 25 min 47 s ± 2 min 46 s, with an overall HRmean of 90.9 ± 1.40% of their HRmax. The average value of the HRpeak was 95.8 ± 1.82% of the HRmax, with a HRmin = 62.2 ± 8.01% of the HRmax. The HR profile was classified into four intensity zones as a percentage of the HRmax. The skiers spent 66.8±23.6% and 31.8±23.8% of the total trial time above 90% HRmax and at 80-90% of the HRmax, respectively, whereas activity in the lower zones was negligible. A progressive increase in intensity was observed during the race: HRmean rose by 2.4% on the final versus the first lap ($p<0.001$; effect size (ES) =1.20, large). The skiers decreased speed on the second ($p=0.017$; ES=0.54, moderate) and third laps ($p<0.001$; ES=0.68, moderate), as compared to the first lap. On the fourth and final lap the skiers increased their speed slightly, but without any statistical difference. The speed maintained by the skiers resulted in the adoption of a reverse J-shaped pacing strategy. CONCLUSION: The present study showed that young well-trained skiers performed a 10-km skating race remaining at a very high intensity for the entire duration of the event with a reverse J-shaped pacing strategy. The analysis of the HR response and pacing strategy suggest that the skiers may have benefited from the use of a more constant speed over the duration of the ski race. REFERENCES Formenti, D., Rossi, A., Calogiuri, G., Thomassen, T. O., Scurati, R., & Weydahl, A. (2015). Exercise intensity and pacing strategy of cross-country skiers during a 10-km skating simulated race. Research in Sports Medicine, 1-14. doi: 10.1080/15438627.2015.1005298.

VO2peak in V2 Roller Skiing and Uphill Running with Poles in Elite XC Skiers

Hynynen Esa , Vesterinen Ville , Mikkola Jussi , Nummela Ari

INTRODUCTION Maximal aerobic capacity is one of the most important factors limiting cross country (XC) skiing performance. There are numerous ways to perform the test of maximal oxygen uptake (VO2peak) and we have previously found no differences in the VO2peak in V2 roller skiing and running with poles in national level XC skiers (Hynynen et al. 2013). While testing higher level athletes, a question has been raised whether the speed becomes limiting factor in the end of V2 test before the "true" VO2peak is achieved in elite XC skiers. Therefore, the purpose of this study was to compare VO2peak in a V2 test and an uphill running test with poles in elite XC skiers. METHODS VO2peak was measured with a portable gas analyzer (Oxycon Mobile, Jaeger, Germany) in two different tests of maximal aerobic capacity. In addition to a routine (30-min) V2 test on 5 % inclined treadmill in August 2016, a short (8-min) uphill running test with poles was performed on the day before the V2 test. Four distance and four sprint specialized men and four women performed the requested tests and the highest 30-sec average of VO2 was selected as VO2peak value for each test. Blood lactate concentration was analyzed after exhaustion (post 1 and 3 min, the higher used as peak value) and heart rate was recorded throughout the test and the highest 10 sec average was used as the peak value. RESULTS VO2peak was found to be higher in running vs. roller skiing in absolute values (5.08 ± 1.00 vs 4.84 ± 0.83 L/min, P = 0.008) and in relative to body mass (70 ± 6 vs 66 ± 7 mL/kg/min, P < 0.001). No differences were found in peak heart rate (191 ± 5 vs 190 ± 5 bpm, P = 0.012) or peak blood lactate concentration (13.4 ± 2.6 vs 13.0 ± 2.4 mM, P = 0.129). In men, FIS distance points correlated with VO2peak (only as relative to body mass) in V2 (r = 0.822, P = 0.012) and in uphill running with poles (r = 0.915, P < 0.001). FIS distance points correlated also with the maximum performance i.e. maximum speed in V2 (r = 0.769, P = 0.006) and oxygen demand in uphill running with poles (r = 0.930, P < 0.001). No correlation was found between FIS sprint points and measured physiological variables. DISCUSSION & CONCLUSION VO2peak was found to be 6 % lower in V2 than in uphill running while no difference was found in other measured physiological values. However, the difference may be partly explained by different protocol, as the duration of the tests was also different. An unexpected finding was that the VO2peak in uphill running with poles had higher correlation to FIS points, even though technically roller skiing is assumed to be closer to skiing on snow. Both test methods correlated well with FIS points and can be used as VO2peak tests for XC skiers. REFERENCES Hynynen E, Mendia I, Monahan K, Kyröläinen H. (2013) VO2max, Aerobic and Anaerobic Thresholds in Five Test Modes on Treadmill in Cross Country Skiers. 6th ICSS, p 96.

Biomechanically-based ACL rupture-mitigation with 3-mode alpine ski-bindings.

Howell Rick

Introduction: In alpine skiing, ACL-ruptures are the most prevalent injury. Body-size; age; gender; knee-flexion; magnitude, position & direction of vectors applied into the ski; menstrual stage; diet-history; proprioception; varying strain-gauge attachment methods; definition of elongation at 'rupture'; and other factors associate with the quantification of ACL-rupture. Shaped skis produce 2 abduction forces that generate a single resultant abduction centroid. Ordinary 2-mode-release alpine bindings address tibia-fracture, only. Aim: Test,

biomechanically, ordinary 2-mode bindings and 3-mode bindings (with additional non-pre-releasing lateral-heel-release) in regard to their release-limits against theoretical ACL-rupture in the presence of abduction-dominant events. Design: A ski is affixed to a metallic foot-tibia-femur. The proximal end of the metallic femur is rigidly attached to the test frame as during maximal internal rotation. The ski is rigidly bolted to the base of the metallic foot including a spacer-block to simulate average boot and binding thickness. Abduction force is applied to a range of positions along the aft medial edge of the ski while measuring peak applied abduction force, peak resultant abduction/valgusmoment, and peak resultant tibia-torque—at theoretical ACL rupture— according to a validated theoretical ACL-rupture algorithm of an average US male with 27-degrees of knee-flexion. The spacer-block is then substituted with an ISO Test Sole plus 2-mode, then 3-mode, bindings—to quantify release-interaction relative to theoretical ACL-rupture. Results: Abduction force applied between -70cm to -20cm aft of the projected axis of the tibia with magnitudes of 155N to 200N (21% to 27% of average body weight of a US-male) cause theoretical rupture of the ACL before tibia-fracture. 3-mode bindings release below these position-dependent theoretical ACL-rupture thresholds. 2-mode bindings cannot release below these position-dependent theoretical ACL-rupture thresholds irrespectively of release settings. Conclusions: The quantitative values presented in this study should not be overapplied. The method may provide a bona fide basis for relative-comparison of ski-binding response to simulated theoretical rupture of the ACL.

Ski Binding Loads Generated During Alpine Skiing and Alpine Touring Skiing: A Comparison of the Retention Requirements

Campbell Jeffrey , Scher Irving , Stepan Lenka , Campbell Kristin , Nichol Jonathan , Ching Randal

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Introduction Alpine touring (AT) is a discipline of skiing in which the skier uses skis to ascend and descend snow-covered terrain in the backcountry. Some AT ski boots use metal fittings to interface with Tech/Pin bindings. This study aims to quantify loads transmitted through the toe and heelpieces during skiing on and off-piste using Alpine and Tech/Pin bindings. Methods Thirteen volunteers (N = 7 males, N = 6 females) skied down an expert slope at a North American Ski resort on the instrumented skis; each trial included off-piste and on-piste slopes and were repeated for the dominant non-dominant leg, on representative Tech/Pin and Alpine bindings. To measure the force and torque transmitted by the toe and heel pieces of ski bindings, custom low-profile (29.2 mm high) 6-axis load cells (Resolution: Force: 0.06 N, Torque: 0.008 Nm) were mounted between skis (Dynastar Cham 97, France) and the ski binding components. During on-snow testing, the load cell data were sampled at 2400 Hz using a 16-bit data acquisition system (DTS, CA, US). Comparisons of loads transmitted through the toe and heelpiece were performed. Force and torque data from the toe and heel piece were resolved about a point under the axis of the tibia and transformed to the top of the skiers boot for comparison to the release torque envelope specified by ISO 8061:2015. Results Using the measured forward lean and twisting torques, a 99% confidence interval was calculated and compared to the retention-release envelope for forward lean and twist specified by ISO 8061:2015. The 99% confidence intervals rarely exceeded the prescribed retention-release envelope for both the Alpine and Tech/Pin bindings. AT bindings released close to or inside the release envelope. During testing, these releases were perceived to be inadvertent (released occurred before the fall, or during sidestepping). Other load components were likely driving the inadvertent release. Alpine bindings released close to the release envelope limit, but were not perceived as inadvertent

(release occurred during a fall). Other non-releases from Alpine bindings significantly exceeded the release enveloped. Alpine binding toe and heelpieces transmitted the loads relatively equally. In contrast, the toe piece of Tech/pin bindings transmitted approximately 70% of the load, relative to the 30% by the heelpiece indicating the path of load transmission differs between the two bindings. Conclusion These results indicate that the retention-release envelope prescribed by international standards is sufficient to provide minimum retention performance for the alpine and alpine touring skiing during our testing. These results indicate that Tech/Pin bindings are not fully capable of performing within the retention-release envelope prescribed by international standards.

Design of skis with non tailored snow interaction. A reverse commercial approach

Sancho Jose, Sancho Alberto

INRODUCTION In the current talk, the design and calculation of sandwich skis based on existing constitutive snow models will be presented. There are several papers about boundary conditions to be used in the design of alpine skis. Nevertheless, its use with conventional finite element software is not such a straightforward issue given that the introduction of non-linear formulated boundary conditions is not allowed by all the commercial codes. Some of the design models developed by brand new Spanish manufacturer, Boreas, will be presented and their interaction with snow will also be discussed. These numerical models may lose some of the characteristics of the analytical ones, mainly in all the aspects regarding depth of footprint and snow penetration, but allow for a proper bending stiffness distribution greatly useful for the whole design of the ski and its riding performance. METHODS Commercial non-linear finite element software MSC.MARC was used along the study and snow characteristics were obtained from bibliographic analysis. The reverse approach proposed is based mainly on assuming a bending curve before starting the simulation, and introducing afterwards the loads on the ski to check the pressure distribution under the ski. This approach to the assessment of the behaviour of a ski requires non-linear calculations with large deflections, contacts between the ski and the snow, and non-linear material models for the snow. Skis designed and manufactured by Boreas were tested both as a full finished product as well as subproducts along their development. Both laminates as sandwich structures were tested in the State University of Navarra materials laboratory to assess both their elastic properties as their mechanical strength to ensure a maximum quality and safe product. CONCLUSIONS AND FUTURE WORK As a conclusion, a reverse approach with non-tailored model of the interface between a turning ski and the snow has been developed. This approach, while having many potential advantages for its universality, still needs much work to improve the easiness of use. Results are quite in accordance with those shown in other works but more models and parameters are still under investigation for reaching even better results and faster calculations. More detailed evaluation of the mechanical response of the ski structure, including dynamic analysis and damping materials inside is being carried on between Boreas and the State University of Navarra.

Does ski width influence muscle activity and ski actions in an elite skier? a case study

Seifert John , Nunnikhoven Heidi , Snyder Cory , Kipp Ronald

Introduction: Sales of wide skis (WS; > 85 mm underfoot width) accounted for nearly 60% of total North American ski sales in 2014-15. Zorko et al. (2015) reported significant differences between wide and narrow ski widths on knee joint kinematics. Those authors reported skiers had more knee extension and less internal knee joint rotation on WS than when on narrow skis. The purpose of this case study was to investigate the differences in muscle activity, ski, and skier actions in an elite skier when skiing slalom skis (SL) and WS. It was hypothesized there would be an increase in muscle activity and skier actions to counter the increased lever arm of the WS compared to SL. Methods: Following IRB approval, a former Olympic GS gold medalist, who is also an elite level ski instructor and national demonstration team member, consented to participate. She completed a run on SL skis (66 mm underfoot) and a run on wide skis (95 mm underfoot). Each run was divided into standardized turns with 13 brushes at a diagonal distance of 15 m and a free ski section. The slope was groomed the night before testing. A Delsys Trigno wireless EMG system (Boston, MA) was used to capture EMG signals from the gluteus medius (GMED) and maximus (GMAX), rectus femoris (RF), vastus medialis (VM), tibialis anterior (TA), and peroneus longus (PL). An RMS analysis was used to assess the EMG signal. Sampling frequency was 1000 Hz. A Biometrix goniometer measured knee flexion/extension at 1000 Hz. A 9 channel motion sensor, measuring at 100 Hz, was used to define turns and ski edge angles (Electronic Realization, Bozeman, MT). The first two turns were dropped from the analyses as the skier was not at a consistent speed. The next five right foot turns were used in analyses. Results: Turn time was 35% slower and ski edge angle 15% less for WS than SL during free skiing. In the brush course, turn time was 16% slower and edge angle 12% less with WS compared to SL. Percent of turn where peak edge angle occurred was 24% earlier for WS than SL in the brush course. RMS values for GMED, RF, VM, and TA were less (average of about 24%) in the WS trial than SL during the free skiing section. However, only the GMED RMS data was less for WS than SL when skiing in the brush course. The GMAX and PL RMS values were greater for WS than SL in the free skiing and brush course (GMAX: by 131% and 116%; PL: by 23% and 27%). Average knee angle was substantially greater for WS than SL during free skiing (136 vs. 118 degrees), but similar for the brush course (116 vs. 113 degrees). Conclusions: Skiing WS substantially changes skier movements, muscle activity, and ski actions compared to SL. The present study's data support Zorko's et al.'s findings in that skiers ski with a greater degree of knee extension on WS than with narrow skis. The higher RMS values for most of the muscles during free skiing on SL were expected due to the turn characteristics and forces encountered by the outer leg while turning as has been previously reported. The greater GMAX values during free skiing and the brush course with WS may be indicative of greater effort to maintain pelvic stability, increased hip extension, or greater lateral femoral rotation compared to SL. The increased lever arm of the WS may also explain the greater PL activity through eversion when edging. These data demonstrate that there is a substantial shift in ski technique as well as changes in muscle activity with WS. It is recommended to use a larger sample pool to assess muscle stresses due to ski width in the general skiing population. Reference: Zorko, M, et al. J Sports Sci & Med. 2015.

3D Printing of ski boots structural parts: comparison of printing methods and materials

Colonna Martino , Gioia Claudio , Debon Federico , Speranzoni Alessandro

INTRODUCTION The highest cost in the development of a ski boot lies in the preparation of the moulds for the injection moulding process of the external shell, which can cost up to 50000 euro for each size. Moreover, the production of a mould can require up to 4 weeks, which significantly retards the development process. For this reason, ski boot manufacturers are looking for rapid prototyping techniques (in particular 3D printing) in order to decrease the time and costs of the development process. Materials for ski boots must complain to several thermo-mechanical characteristics (e.g. resists to impacts at temperatures as low as -20°C and have the correct flexural and damping properties) to be efficiently and safely used. At the moment, the materials used for 3D printing lack of the characteristics necessary to produce a ski boot prototype. Therefore, the aim of this work has been the comparison of the techniques and of the materials available for 3D printing in order to determine the changes necessary to obtain prototypes with performances and safety characteristics that permit their use in on-snow tests. METHODS We have prepared test specimens and ski boot parts using Selective Laser Sintering (SLS) and Fuse Deposition Modelling (FDM) techniques. The test specimens have been prepared using 3 orthogonal orientation of growth in order to determine the anisotropy of the materials. DMTA analysis has been used to measure the stiffness and damping behaviour of the materials while Izod tests at 23°C and -20°C to assess their impact resistance. Ski boot parts have been analysed in test benches that measure the flexural stiffness of the boot and the force needed to release the boot from the binding. RESULTS AND DISCUSSION DMTA analysis has shown that all the materials present a strong anisotropy (especially those made by FDM) and posses elastic moduli above 1.2 GPa at 23°C. However, SLS printed Nylon composites do not get stiffer lowering the temperature, and therefore the stiffness at -2°C is similar to that of some of the plastics used in ski boots. The Izod impact tests show that the parts produced by SLS and FDM maintain their impact resistance at -20°C. However, the values measured (20-30 J/m) are too low to permit their use in on-snow tests. On the basis of the results obtained we have developed, together with CRP Group, a new composite material based on impact modified Nylon 12 containing carbon fibers, that possess a modulus of 1 GPa and a impact resistance at -20°C of 90 J/m, that makes the material suitable for the use in ski boots. Indeed, ski boots made with this material have been tested on-snow and in lab test benches demonstrating that it is possible to use them in the development process of ski boot. CONCLUSIONS The results obtained indicate that it is possible to prepare ski boot prototypes by 3D printing that can be safely skied. However, new materials must be developed in order to produce parts that are now made with materials with a stiffness of 100-500 MPa.

Ski bindings, inadvertent release, and ACL injuries

Brown Christopher A., Bell Shane M., Madura John M.

INTRODUCTION Binding designs for avoiding ACL injuries (3) and inadvertent release (IR) are studied here, particularly for alpine ski racers. Increasing ski side-cut (5) has not dramatically reduced ACL injuries (3) and this adversely impacts the attractiveness of ski racing (5). ACL injuries first increased in the 1980s when boots got stiff in backward lean, well before shaped skis appeared. Bindings are effective at filtering injurious loads to the tibia, but fear of IR leads to extreme settings, potentially rendering bindings ineffective at filtering injurious loads to the ACL, unless IR is addressed. METHODS Axiomatic design (AD) is applied to ski bindings, avoiding potentially injurious loads, while faithfully transmitting control loads and avoiding IR. AD

maintains functional independence and selects the most robust physical solutions. Designs are developed in rigorous, hierarchal, functional-physical decompositions. This research relies on the design axioms and mechanical analysis to identify the best design. RESULTS and DISCUSSION To protect the ACL, bindings must respond to combined valgus and inward rotation loads (CVIR), and boot induced anterior drawer loads (BIAD), which are known to cause ACL injuries. To avoid IR bindings must respond rapidly to shocks and flexing of the ski. Conventional, two mode bindings used currently on the World Cup do neither. Bindings need to respond laterally at the heel and vertically at the toe or heel. Mechanical solutions exist for controlling these elements independently and robustly. These solutions can work for elite, alpine ski racing. CONCLUSIONS Bindings can be designed to protect the ACL (1,4) and resist IR (2,4,6). FIS efforts to mitigate ACL injuries should include promoting better binding design and adjustment strategies. IR should be monitored and studied. REFERENCES 1. Brown, C.A., & Madura, J.M. (2016a). U.S. Patent No. 9,339,719. Washington, DC: U.S. Patent and Trademark Office. 2. Brown, C.A., & Madura, J.M. (2016b). US Patent 9,358,447 Washington, DC: U.S. Patent and Trademark Office. 3. Haaland, B., Steenstrup, S.E., Bere, T., Bahr, R., & Nordsletten, L. (2016). Injury rate and injury patterns in FIS World Cup Alpine skiing (2006–2015): have the new ski regulations made an impact? British journal of sports medicine, 50(1), 32-36. 4. Howell, R.J. (2015). U.S. Patent No. 8,955,867. Washington, DC: U.S. Patent and Trademark Office. 5. Müller, E., Spörri, J., Kröll, J., & Hörterer, H. (2016). Equipment designed to reduce risk of severe traumatic injuries in alpine ski racing: constructive collaboration between the International Ski Federation, industry and science. British journal of sports medicine, 50(1), 1-2. 6. Madura, J.M., & Brown, C.A. (2015). Protecting the ACL in Alpine skiing with load-limiting binding plates. Science and skiing VI Müller et al., eds. Aachen: Meyer & Meyer.

The conceptual framework of evidence-based classification applied to Nordic Skiing for athletes with intellectual impairment

Vanlandewijck Yves , Van Biesen Debbie , Danvind Jonas , Blomqvist Sven

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To be allowed to participate in International Paralympic Committee (IPC) sanctioned events, two requirements need to be fulfilled: 1) the health disorder of the athlete should be clinically documented, and 2) the impairment resulting from the health condition should have a direct and significant impact on sport-specific performance (Tweedy & Vanlandewijck, 2011). By the authors' knowledge, studies on the impact of intellectual impairment (II) on Nordic Skiing performance are non-existing. The conceptual approach to study this relationship has been established by the INAS-IPC research group (Van Biesen et al. 2016): first, the cognitive factors that impact on sport-performance in general are measured in a generic way. It is expected that athletes with II in general will underperform significantly on spatial memory, inductive reasoning, visual processing and executive functioning. In the second step, the determinants of sport performance – mainly impacted by the impairment – are measured in a sport-specific way. The third and final step consists of performance observation during competition. In a study on elite Nordic Skiers with II (19 men, 4 women), the significant underperformance on generic sport-intelligence of athletes with II compared to an able-bodied control group (AB: 107 men, 55 women), matched for volume of training, was confirmed (spatial memory [CORSI] 3.73 ± 1.16 vs. 6.7 ± 0.9 units of information; inductive reasoning [WASI Matrix] 13.04 ± 6.48 vs. 29.1 ± 3.6 points; visual processing [WASI Block] 16.88 ± 12.36 vs. 58.8 ± 9.7 points; executive functioning

[Tower of London] 8.13 ± 3.57 vs. 11.8 ± 3.1 number of items). In an explorative Nordic skiing specific test at submaximal speed, significant differences were found for double poling velocity between II-skiers (3 men; 2 women) and AB-skiers (16 men; 8 women). In the diagonal stride-technique, a significantly lower velocity was accompanied by a reduced pole-length and a higher pole-frequency in both male and female II-athletes. These results were confirmed for speed and pole-length, skiing freestyle in the 2nd and 4th gear. In a second explorative Nordic Skiing specific pacing test in the same sample, no differences were found in pacing accuracy in classic and freestyle between II and AB athletes. Observation during a classical sprint event (22 II – 6 AB men; 6 II – 7 AB women) revealed different decisions on how athletes adapt skiing techniques to differing external conditions. While II-athletes shift from double poling on a flat terrain to diagonal stride during fair to moderate inclination, AB-athletes persist in the double poling technique on steeper slopes. AB and II- female athletes, however, apply the diagonal stride already on less steep slopes compared to men. The above studies confirm the significant underperformance of II-athletes on generic sport-intelligence. Sport-specific tests and observation during the races are less discriminant between II and AB-athletes. Important differences in physical and skill proficiency levels might have obscured the results.

Optimization of Paralympic Winter Sports Performance

Perret Claudio

PURPOSE: The level of Paralympic winter sports performance has considerably increased over the past few years and winning or losing a competition in Paralympic winter sport championships is often a matter of a split second. In other words: every single detail counts, which underlines the necessity of optimizing training interventions and equipment for these athletes in order to achieve top class performance. METHODS: The present talk will discuss examples of different interventions to improve Paralympic winter sports performance in elite athletes with a spinal cord injury. These interventions mainly focus on respiratory muscle training, but will also take into account nutritional interventions (e.g. caffeine supplementation) as well as individual biomechanical adaptations. Further, personal factors such as level and completeness of the lesion and sport-specific circumstances (e.g. cold environment, altitude) have to be considered. RESULTS: Some studies using respiratory muscle training in wheelchair athletes showed a 1.8% to 11% enhancement in endurance performance, whereas other studies found no effects. Further, the application of an appropriate locomotor-respiratory coupling strategy (e.g. for sit skiing) might help to optimize performance by enhancing breathing work efficiency. If nutritional supplementation is an issue, caffeine might be an option to enhance short term exercise performance in athletes with a paraplegia. In fact, an increase of about 3% in peak and average power over the first minute of a 3min all-out arm-crank test was found after caffeine supplementation. In the field of equipment adaptations, the kneeling position was the most efficient position to achieve the highest velocity in sit skiing. CONCLUSIONS: Respiratory muscle training, supplementation strategies (e.g. caffeine) as well as adaptations of the personal equipment (e.g. sitting position) display the potential to enhance Paralympic winter sports performance. However, due to the limited number of elite athletes with a spinal cord injury available to participate in scientific studies, final conclusions are difficult to draw at this stage and recommendations have to be done mainly on an individual basis in collaboration with experienced coaches or scientists.

Development of a classification protocol for Paralympic sit-skiers

Rapp Walter , Rosso Valeria , Gastaldi Laura , Lindinger Stefan , Pernot Dia , Vanlandewijck Yves , Linnamo Vesa

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In 2011 International Paralympic Committee (IPC) initiated a discussion to improve the classification process in Paralympic Nordic sit-skiing athletes. In order to get a more evidence based classification biomechanical methods should be established in order to get valid and reliable values to improve the objectivity of the classification process and as well to make the process more transparent. Literature referring to the special requirements in sit skiing are rare. Therefore, in order to gets a better understanding about performance in sit-skiing, video samples from 46 athletes competing at Sweden World Cup race 2013 were collected and analysed to get an impression about relevant parameters in sit skiing (Schillinger et al. 2015). From these videos it was obvious that a more "Kneeing" position seems to be connected to more efficient poling with longer cycle length and more trunk movement. This was furthermore supported by laboratory studies with non-disabled athletes at a ski ergometer where in a kneeing position higher poling velocities could be achieved (Rapp et al 2013) and also the energetic expenditure (Lajunen et al 2015) is more efficient in kneeing compared to a position where the knees are over hip level. The latter is adopted by athletes with higher impairment in order to keep the trunk in an upright position. The rules in sit-skiing restrict the sitting height to 40cm and the buttocks must have permanent contact to the sitting platform. Therefore forward propulsion can only be generated by double poling using arm and trunk. Generating forces by the trunk, however, is limited by the level of impairment. Based on this knowledge evaluating trunk stabilization is an essential requirement in sit skiing and must be integrated into a test setup. Therefore a test setup was established where the influence of the athletes own equipment could be excluded. A special device was constructed for recording force production of the upper body (bench press) with and without back support. Furthermore a perturbation test was established. Goal of this perturbation is to move the athlete in an unpredictable way either in anterior or posterior direction or in medio lateral direction and force him to keep the trunk position stable. Both test situations were tested with Paralympic world class athletes and showed a good compliance of athletes and coaches from different nations. These tests and some major results will be shown during the ICSS 2016 Congress. References: Lajunen K, et al. Effect of sitting posture on sit-skiing economy in non-disabled athletes. 3rd International Congress on Science and Nordic Skiing June 5-8.2015, Vuokatti, Finland, p43. Rapp W., et al. (2015). Force production, balance control and muscle activation in different sitting positions – pilot study for disabled sit sledge cross-country skiers. In Book: Science and Skiing VI. Eds. Müller E., Kröll J.,Lindinger S., Pfusterschmied J., Stöggl T. Schillinger, F., et al. (2015). A descriptive video analysis of classified Nordic disabled sit-skiers during the Nordic World Championship 2013. In Science and Nordic Skiing III (pp. 173–179). Finland.

Sports engineering and biomechanical aspects of cross-country sit-skiers

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INTRODUCTION: In cross-country (XC) sit-skiers adopt a pushing gesture very closed to the double poling technique. However, while in standing athletes both upper and lower-body are involved, in sit-skiers the contribution of the lower-body is limited or absent due to the different impairment. The trunk control capacity is a key factor in the understanding the kinematics, kinetics, and the distribution of the workload in sit-skiers. In the frame of "IPC - Nordic sit-skiing classification" project, different tests had been conducted to assess how the impairment influences performances: perturbation test [1], ergometer vs natural skiing [2], uphill and flat skiing. From these tests consideration about the kinematics in sit-skiers can be gathered. METHODS: test on sit-skiers can be divided in lab and in the field/on snow test. In the last group also evaluation during competition might also be taken into account. Tests and measurements were led over the last years on elite sit-skiers during Paralympics and World Championships. Different methodology had been adopted, involving the use of testing equipments which were both conventional (motion capture systems, electromyographs, force sensors, force platforms, etc) and specifically designed (adapted ergometer, perturbation sledges, instrumented poles, custom designed test-bench etc). RESULTS and DISCUSSION: From both simulated and natural skiing it can be pointed out that different skiing strategies are adopted by athletes with different level of impairment. Considering that core stability is a key issue, then a difference can be observed in the trunk ROM between athletes (1) without any (2) partial and (3) complete functional abdominal and dorsal muscles. Moreover considering the mean flexion angle, this increases progressively passing from (1) to (3). The consequences of greater ROM and flexion angle are a more efficient poling, due to the contribution of the trunk muscles and trunk mass, and to a greater pole inclinations with respect to the horizontal. A forward flexion during the poling phase results also in a greater sledge stability and helps in keeping shoulder and elbow joints less extended during the poling phase; therefore to limit fatigue in skiing. When considering skiing in different condition with respect a straight and the flat one, then the biomechanics changes and differences among disabilities are even more evident. For example lateral trunk movement is essential when negotiating a curve. More studies in the field/on snow and/or during competition are desirable, especially when considering uphill sections and curves. REFERENCE: Rosso V, Linnamo V, Rapp W, Lindinger S, Vanlandewijck Y, Gastaldi L. (2016)Trunk kinematics during cross country sit-skiing ergometry. IEEE Int Symp Med Meas Appl. Rapp, W., Rosso, V., Ohtonen, O., Gastaldi, L., Vanlandewijck, Y., Lindinger, S., & Linnamo, V. (2016). Role of muscle activation in the sit-skiing performance and classification process. In Science and Nordic Skiing III (pp. 165–172). Finland.

Evaluation of two sitting positions in cross-country sit-skiing

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INTRODUCTION In cross-country sit-skiing (CCSS) athletes with reduced trunk control mainly sit with their knees higher than the hips (KH) to increase trunk stability. To improve the spine curvature by reducing kyphosis a new sitting position was created where the knees were lower than the hips by help of a forward trunk support (KL). The aim of this study was to evaluate the new KL position and compare it to KH in terms of physiological and biomechanical measurements as well as musculoskeletal simulations. METHODS Five abled-bodied female

cross-country skiers (62.6±8.1kg, 1.67±0.05m) performed two sets of tests; one in each sitting position on a skiing ergometer (ThoraxTrainer A/S, Denmark). Each test comprised a 30s all-out test (AO), an incremental submaximal test (4 to 6 x 3 min, SUB1-SUB6) and a maximal time-trial test of 3 min (MAX). During SUB and MAX external power, pole forces and kinematics were measured. Metabolic rates (MR) were calculated from oxygen consumption and lactate concentrations. The AnyBody Modelling system (AMS 6.0, Anybody Technology A/S, Denmark) were used to simulate full-body musculoskeletal models over 4 poling cycles of SUB2, SUB4 and MAX. From the simulations muscular metabolic rate (mMR) and musculo-skeletal efficiency (ME) were computed (Holmberg et al., 2013). RESULTS & DISCUSSION The performance (W/kg) was higher in KH in both AO (24%) and MAX (32%). KL had more flexed knee, more extended hip and less kyphosis in trunk, while KH had larger range of motion (ROM) in hip and larger flexion and ROM in spine at SUB4 and MAX. Gross efficiency (GE) was higher in KH. The total MR and ratio of anaerobic MR to total MR were higher in KL at SUB3 and SUB4. Simulations showed that 4 subjects had higher ME in KH for both SUB4 and MAX, though no statistical significance were observed. mMR were higher for KL at SUB2 and SUB4 but it was higher for KH at MAX. The ratio of mMR in body parts to total mMR showed higher ratio for KL in arm-shoulders (6.7-9.1%) and higher ratio for KH in trunk (3.7-4.6%) and hip-legs (3.0-4.6%). CONCLUSION The physiological results were comparable to others (Lajunen, 2014 & Verellen et al, 2012) and the simulation results were novel by showing how the motion of the trunk contributes to the total metabolic rate. KH position showed higher performance and GE while the KL position indicated higher mMR for arm-shoulders, and had also higher anaerobic MR. Therefore the KH position is favorable for abled-bodied athletes because KL limits trunk motion. REFERENCES Holmberg, L. J. et al. (2013). Comput Methods Biomech Biomed Engin, 16(9), 987-992. Lajunen, K. (2014). Effect of sitting posture on sit-skiing economy. Bachelor's thesis, University of Jyväskylä. Verellen, J. et al. (2012). Eur J Appl Physiol, 112(3), 983-989

Tribological optimization of sit-skis

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A sit-ski is a device that allows a disabled athlete to perform cross-country skiing. As a rule, sit-skis are custom-made and can be divided into two main parts, the ski and the seat. Whereas the ski is a commercial product, the seat reflects the special requirements of the athlete. Therefore, skiing position as well as frame and cushioning differ from case to case. Due to different skiing positions – kneeling or sitting – the mechanical interface between seat and ski varies from athlete to athlete and leads to different pressure distributions along the ski. These differences in turn influence the gliding performance and the way the athlete is able to maneuver the sit-ski. As an example: For the skiing position legs forward, i.e., sitting, the maximum load may be located in front of the binding. As a result, the skis points into the snow rendering turning or lane shifting difficult. Additionally, the pressure distribution influences the contact geometry between ski sole and snow which is essential for the frictional resistance. In order to reduce friction, the contact area has to be minimized. This is accomplished by the joint action of the grinding structure and the tension of the ski. A ski with high tension contacts the snow with tail and shovel. This approach usually works for a standing cross-country skier but might be detrimental for an athlete who sits on skis that are not allowed to be independently lifted. To meet the different requirements, athletes with their sit-skis were placed on a high-resolution

pressure plate with a length of 2 meters. The plate was that sensitive, that in addition to the overall pressure distribution, local pressure peaks introduced by the grinding structure were made visible. In a first set of tests the athlete executed static loads. Then bending and rocking motions were added. Finally, the introduction of peak loading due to double poling was investigated. Data evaluation was performed using digital photos of the athlete´s posture with regard to the accompanying pressure distribution. To consider the dynamic behavior, video sequences were used. The result of the tests allowed to derive design rules for the dimensioning of cross-country skis. In addition, the grinding structures were optimized in order to consider the special requirements of the athlete with respect to weight distribution and dynamic loading.

Changing the ski regulation to protect the athlete's knee: What was the justification? What do the data tell us? What did we learn?

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INTRODUCTION: The International Ski Federation (FIS) established the FIS Injury Surveillance System in 2006 with the aim of developing and implementing effective prevention measures to protect the health of athletes. One concrete prevention measure was the introduction of new ski regulations for the season 2012/2013. The FIS decision was based on various studies characterizing the epidemiology, risk factors and mechanisms of injuries in alpine ski racing.[1-4] Therefore, the first part of the presentation will provide an overview on the published work in these areas. Recently, the effect of the adapted ski regulations was assessed by comparing the injury risk prior an after the implementation.[5] The overall relative injury rate during World Cup racing was reduced significantly by 24% in the three seasons after implementation compared to the six seasons before. Nevertheless, it is important to explore how the injury data was developed with respect to the primarily prevention goal of the new ski regulations - the athlete's knee. Therefore, the aim of the second part of the presentation is to illustrate the incidences of ACL ruptures (expressed as the relative ACL-injury rate) prior to and after implementing the new ski regulation. METHODS: Since the season 2006/07 periodical retrospective interviews were conducted on World Cup level by the Oslo Sports Trauma Research Center.[1] Data from the six seasons before (PRE) and the four seasons after (POST) the change in ski regulations are compared with respect to relative ACL-injury rates (injuries per 1000 competition runs with exact 95% CI) for the disciplines Downhill (DH), Super-G (SG) and Giant Slalom (GS). POST/PRE risk ratios (RR) are presented with their 95% CI. RESULTS: The exposure for the six considered conditions ranged from 3012 to 6903 runs. The observed ACL cases ranged from 5 to 13. For all three disciplines the relative ACL-injury rates did not significantly differ between PRE and POST: DH-PRE 2.08 (1.11 to 3.56) / DH-POST 2.02 (0.87 to 3.99); SG-PRE 1.36 (0.50 to 2.97) / SG-POST 1.66 (0.54 to 3.87); GS-PRE 1.88 (1.00 to 3.22) / 1.22 (0.49 to 2.51). The RR was 0.97 (0.40 to 2.34) for DH, 1.22 (0.37 to 3.98) for SG and 0.65 (0.26 to 1.62) for GS. DISCUSSION: Similar to earlier results[5], four years of observation do not allow to draw conclusions on the effects on ACL injuries in specific disciplines due to limited statistical power within subgroups. By definition statistical power is determined by the sample size and the effect size. The FIS Injury Surveillance System already captures injury and exposure data on 75% of all World Cup skiers.[1] Therefore, an increased sample size can only be reached by extending the sample towards lower level racing. By doing so, the considered population

becomes more heterogeous which, again, severely reduces the chance to draw appropriate conclusions. The aspect of effect size can be examplified on the discipline GS: Although the effect size expressed by RR for GS was 0.65 (i.e. 35% risk reduction), no significant difference was observed. Theoretically a 91% risk reduction would be necessary to show significant differences within the given sample size, which is far from realistic for a single intervention to prevent a multi-causal injury. CONCLUSION: In elite alpine ski racing a deterministic approach to assess whether a prevention measure is effective or not is almost impossible since study power is likely to be undermined when dealing with such small cohorts and targeting on specific body regions, like the athletes knee. REFERENCES [1] Florenes et al. (2009). Br J Sports Med, 43(13), 973-978. [2] Spörri et al. (2012). Br J Sports Med, 46(15), 1059-1064. [3] Bere et al. (2011). Am J Sports Med, 39(7), 1421-1429. [4] Müller et al. (2016). Br J Sports Med, 50(1), 1-2. [5] Haaland et al. (2016). Br J Sports Med, 50(1), 32-36.

Can we predict where accidents occur on World Cup alpine ski racing courses?

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INTRODUCTION: Alpine ski racing is considered a sport with high injury risk. In World Cup (WC), most injuries per run occur in the discipline downhill (DH) (Florenes et al., 2009). Recent studies have shown that injury risk in DH is related to speed, race duration and jumps (Gilgien et al., 2014). Following-up these findings, this study investigated whether accidents in male World Cup alpine ski racing are equally distributed along WC DH courses or whether there are specific spots with increased injury risk identifiable. Further, it was assessed what the course, terrain and skier mechanical characteristics are at locations where accidents occur. METHODS: For the study the male WC DH races of Lake Louise (CAN), Beaver Creek (USA), Wengen (CH) and Kitzbühel (A) were analysed. Potential injury risk locations (IRL), i.e. locations where skiers left the course, fell or got injured, were determined from official TV footage of the respective WC races (Lake Louise 5 years, Beaver Creek 5 years, Wengen 5 years and Kitzbühel 5 years). Course settings and terrain characteristics (steepness, roughness) were captured and derived as described in (Gilgien et al., 2015a). In each race one male forerunner skied the course equipped with a dGNSS, tracking the skiers head trajectory (Gilgien et al., 2015b). The dGNSS data and the digital terrain model were used to compute the center of mass position, speed, turn radius (R) and the ground reaction force (GRF) (Gilgien et al., 2013). To determine whether IRL were equally distributed along the course their occurrence was expressed as distance from start along the course and a Chi-Square goodness of fit test was applied. At the IRL and non-IRL, the terrain characteristics as well as the mechanical characteristics of the forerunners were derived. For each of these parameters IRL and non-IRL were compared by means and a two–sample Kolmogorov–Smirnov test to assess the correspondence of their histograms. RESULTS: The IRL were not equally distributed along the courses. None of the skier mechanical and course characteristic parameter distributions were equal between injury and non-injury risk situations. At IRL mean speed was 23 m/s (non-IRL: 22m/s), mean R was 74m at IRL (non-IRL: 205m), mean IRL GRF was 1.4 BW (non-IRL: 1.1BW). Terrain inclination at IRL was 16 deg.(non-IRL:15 deg.) and the course was at a 35 (non-IRL: 33 deg.) angle to the fall line. DISCUSSION AND CONCLUSION: Injuries and potential injury situations are not equally distributed along DH courses, but occur at specific spots. These occur typically, in turns, where the terrain is tilted side-ways and when skiers ski at about mean speed. These findings might help to target safety measures to where accidents likely happen.

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ADAPTING A SCHOOL-BASED INJURY PREVENTION PROGRAM TO REDUCE INJURY RISK IN YOUTH ALPINE RACERS: A PILOT STUDY

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INTRODUCTION: Providing exercises and training recommendations specific to alpine ski racers is important for both injury prevention and reducing the prevalence and cost associated with alpine winter sports injuries.[1] A recent systematic review related to Alpine skiing, however made “no recommendations towards physical fitness, exercise and/or training per se, or its role in preventing injury.”[2] Seed funding was received from the Faculty of Kinesiology to purse the BASE IPS study (Balance Acquisition Strength Exercises for Injury Prevention in Skiers). Given our injury prevention expertise, previous research was used to develop a sport specific neuromuscular training (NMT) program for Alpine ski racers in Southern Alberta.[3,4] This study purpose is to: examine the effectiveness of a neuromuscular prevention strategy in reducing injury risk in youth alpine ski racers. METHOD: The intervention training program involves twice weekly coach (educated) delivery of dynamic stretching, eccentric strength, agility, jumping and balance and includes a home-based balance training program using a wobble board. The control program is a coach delivery of the standard dryland training completed yearly involving outdoor aerobic and static stretching components. Statistical analyses will include adjusting for age, sex, and mean weekly hours of sport participation, to assess the association between previous sport injury (yes/no) and followed by a linear regression for performance measures. RESULTS: The programme (ongoing Sept. to Nov.) involves 30 (53%M) athletes (mean weight: 45 kg, height 161 cm) in a U14 program from one club in southern Alberta. Performance outcomes are: 20-m shuttle run (aerobic), vertical jump (lower body musculoskeletal), and the Y-balance and unipedal eyes closed balance tests (static and dynamic balance). DISCUSSION: A large number of athletes are needed to evaluate the effectiveness of a NMT. This pilot data will be included in larger grant that seeks to involve all southern Alberta ski clubs. CONCLUSION: There is limited published data that investigates sport specific NMT in youth alpine ski racers. We believe that a NMT program will be protective of lower limb injuries in youth alpine racers and improve performance outcomes associated with static and dynamic balance. REFERENCES 1. Emery C, Richmond S, Doyle-Baker T. (2010). The effectiveness of neuromuscular training in the prevention of injuries in youth: Do we have enough evidence? Where do we go from here? JSMS 12(2):e18-e19. 2. Hébert-Losier, K. & Holmberg, H. (2013). Sports Med 43: 355. 3. Richmond S, Kang J, Doyle-Baker PK, et al. (2015). A school-based injury prevention program to reduce sport injury risk and improve healthy outcomes in youth: a pilot, clustered randomized controlled trial. CJSM, in press. 4. Richmond S, Emery CA, Doyle-Baker PK, et al.(2011). Preventing lower extremity sport injury through a high intensity neuromuscular training program in a junior high school setting. BJSM, 45:313-314.

Dynamics of Snow Park Jump Landings: A Pilot Study Examining Impact Loads

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Introduction Snow parks are a relatively recent addition to trails at ski resorts. Previous studies indicate that jumping features have higher injuries rates than non-jumping features for the general public and possibly for elite athletes. The kinematics and loads produced by snowboarders while using competition-sized, tabletop features in snow parks has not been studied widely. Ascertaining the jumper kinematics and loads produced could provide guidance for considerations and interventions used to reduce the loads on the body and likelihood of injury. In this study, we measured the landing loads and body kinematics of snowboarders while landing on competition-sized jumps, similar to those found in slopestyle and big air competitions, to assess whether or not the equipment and methodology would be appropriate for use in a more complete, long term study. Methods A pilot study was conducted on a set of two consecutive, competition-sized jumps at Squaw Valley Ski Resort in Olympic Valley, CA, USA. The jumps were designed and fabricated by Snow Park Technologies to represent competition level, slopestyle jumps. Before each data collection session, the physical dimensions of the jump were measured and recorded. Three elite level athletes (2 males, 1 female) were instrumented with: (1) a kinematic body suit (Xsens, MVN Biomech Body Suit, Netherlands) containing 17 inertial measurement units; (2) custom low-profile, 6-axis load cells (Resolutions: 0.06 N along each axis and 0.008 Nm about each axis) mounted between their personal snowboards and bindings; and (3) a triaxial collection of accelerometers (Meggitt, Endevco 7264C, CA, USA) mounted on the top surface of the snowboard between the feet. During on-snow testing, the body suit data were sampled at 120 Hz and the load cell and accelerometer data were sampled at 6 kHz using a 16-bit data acquisition system (DTS, NanoSlice CA, USA). Each rider was asked to perform a series of jumps. Peak impact loads and center-of-mass motion at landing were ascertained. Results and Discussion A total of 66 jumps were measured on two large, competition style jumps. The instrumented body suit and snowboarding equipment did not affect significantly the riding ability of the elite snowboarders; all riders indicated that the equipment did not impede their ability to jump. The loads transmitted through the snowboard to the riders upon landing were dependent on the landing orientation of the snowboard. While most landings had large compressive loads exceeding 3 times body weight, some landing orientations (for example, a hard landing on the tail of the snowboard) created tension on one leg and large moments. Impulse times for the landing force were typically under 100 ms. Landing impulse time increased in test trials where the travel distance of the rider's center-of-mass towards center of the board was larger. The equipment and methodology performed well and are promising for assessing lower leg joint loads and conducting a parametric analysis of variables related to injury likelihood.

The effect of ski boot flexion stiffness on jump landings in skiing

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INTRODUCTION: Mogul skiing is a popular skiing discipline which is performed by elite and recreational skiers. Injuries are very common mainly affecting the knee joint. Previously, it has been shown that a flexible boot shaft may allow to improve skiing technique and reduce the loads on the knee joint when negotiating a mogul course (Kurpiers et al. 2011). It has not been

investigated yet which effect these boots may have on landing technique after aerials which are key elements in competitive mogul skiing. The purpose of this study was to compare landing kinetics and kinematics after a jump with a conventional and a modified ski boot. METHODS: Six expert skiers were equipped with a motion capture suit (Xsens, NL) and one ski was equipped with a dynamometric binding plate to measure forces acting in a normal and lateral direction with respect to the ski plate and the pitch moment acting about an axis transverse to the ski (Petrone,2014). One commercially available ski boot (Raptor, Head, A) and a modified boot with a very flexible shaft were compared (Kurpiers et al., 2011). The jump geometry, landing area and six reference points on short sticks in the snow were surveyed by a RTK GNSS system (Leica, CH) with a reference station close to the jump. The reference points were used as calibration points for a two-dimensional video capture of the whole flight phase (50 Hz, Canon EOS camera). A reference point on the skier's helmet was tracked using Skill Spector software (video4coach, DK). The kinematic data of the flight path were transformed by aligning the flight plane with the three-dimensional world coordinate system. Each athlete performed three jumps from three different run-in distances. The video tracks of the head were merged into C3D files and a custom full-body model (C-motion, Visual 3D, USA) was used for kinematic and kinetic analyses. RESULTS: The ski boot affected the dorsiflexion angle at TD, the range of movement during the amortization of the ground reaction forces and the positioning of the CoM in relation to the ski binding, being more forward with the modified boot. DISCUSSION: The collected kinematic and kinetic data enable the investigation of boot modifications on landing technique including inverse dynamic estimates of joint loading and were indicating a safer and more advantageous landing with the modified boot. CONCLUSION: The innovative measurement system enabled analyzing the effects of boot modifications on ski landings which may also be important information for competitive skiers when experimenting with equipment. ACKNOWLEDGEMENTS: ISEA Wintercamp 2015, Tognola skiing resort, San Martino di Castrozza, IT. REFERENCES: Petrone N., Marcolin G., Cognolato M., Hofer, P., Nachbauer, W. (2014), Proc. Eng., 72, pp. 630-635. Kurpiers N., Kersting U.G., McAlpine P.R . (2011) In: E. Mueller, S. Lindinger & T. Stoeggl (Eds.), Science and Skiing V. St. Christoph am Arlberg, Austria, ISBN: 978-1-84126-353-3, 335-345.

Skiing efficiency in world-class distance-specialized and sprint cross-country skiers

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INTRODUCTION: Work economy is one key factor in endurance performance. In addition to technique, neuromuscular characteristics has been associated with work economy. Cross-country (XC) sprint skiers have been observed to be faster and stronger compared with distance-specialized (DIST) skiers (Hebert-Losier et al. 2016). The purpose of this study was to examine gross efficiency (GE) in roller-ski skating in world-class DIST and sprint XC skiers. METHODS: Six male DIST (FIS points distance 28 ± 14) and six sprint XC skiers (FIS points sprint 29 ± 14) performed an incremental roller-ski test on a 5 % inclined treadmill using the G3 skating technique. Oxygen consumption, blood lactate and HR were measured during the test. GE was calculated as the external work rate divided by the aerobic metabolic rate over two submaximal 3 min stages at 14 and 17 km/ h, in accordance with Sandbakk et al. (2010). In addition, maximal aerobic, anaerobic and power production abilities were measured. RESULTS: VO2peak and maximal aerobic speed were greater (both p = 0.03) in DIST (76.2 ± 3.0 ml/kg/min, 23.6 ± 0.9

km/h) compared with sprint skiers (70.2 ± 4.4 ml/kg/min, 22.1 ± 1.1 km/h). Maximal anaerobic double poling speed and power production in squat and bench press tended to be greater (p = 0.07-0.10) in sprint skiers (32.8 ± 1.5 km/h, 800 ± 68 W, 672 ± 134 W) compared with DIST (31.6 ± 1.3 km/h, 694 ± 94 W, 596 ± 61 W). No differences were observed in GE at 14 and 17 km/h between DIST (17.0 ± 0.5 %, 17.6 ± 0.7 %) and sprint skiers (16.7 ± 0.6 %, 17.4 ± 0.5 %). Maximal aerobic characteristics and power production abilities were not correlated with GE. Negative correlations were observed between maximal anaerobic speed and GE at 14 and 17 km/h (r = -0.65, r = -0.63, both p < 0.05). DISCUSSION AND CONCLUSION: World-class DIST and sprint XC skiers showed partly different physiological characteristics. While DIST skiers had greater aerobic abilities, sprint skiers tended to have greater anaerobic and force production abilities, which support the previous findings by Hebert-Losier et al. (2016). However, in the present study, no differences between DIST and sprint skiers were found in skiing efficiency. Previously Sandbakk et al. (2010) observed a higher skiing efficiency in world class sprint skiers compared with national level sprint skiers. Power production abilities are suggested to relate to work economy / efficiency. However, the present results showed that general power production abilities were not related to skiing efficiency in world-class distance-specialized and sprint cross-country skiers. REFERENCES: Hebert-Losier et al. (2016) Sports Med (Epub) Sandbakk et al. (2010) Eur J Appl Physiol, 109, 473-481.

On the effects of upper-body sprint-interval training on maximal strength and aerobic power in female cross-country skiers

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INTRODUCTION: Previous studies have shown that sex differences in cross-country skiers become more pronounced with increasing power contribution from the upper-body and, hence, women may have a particularly large potential to improve their upper-body capacity and DP performance. Therefore, this study compared the effects of adding upper-body sprint-intervals or continuous endurance to female cross-country skiers' normal training regime on maximal upper-body strength and endurance adaptations. METHOD: In total, 17 female skiers (age: 18.1±0.8yr, body mass: 60±7 kg, maximal oxygen uptake (VO2max): 3.30±0.37 L.min-1) performed an 8-week intervention training period. Here, either two weekly sessions of six to eight 30-s maximal upper-body double poling intervals (SIG, n=8) or 45-75 min of continuous low-to-moderate intensity double poling on roller skis (CG, n=9) were added to their training. Before and after the intervention, the participants were tested for physiological responses during maximal diagonal and double poling treadmill roller skiing. Additionally, maximal upper-body strength (1RM) in a poling-specific strength exercise was measured. RESULTS: SIG improved absolute VO2max in diagonal skiing more than CG (8% vs 2%, p<0.05), and showed a tendency towards higher body-mass normalized VO2max (7% vs 2%, p=0.07). Both groups had an overall improvement in double poling peak oxygen uptake (10% vs 6% for SIG and CG) (both p<0.01), but no group-difference appeared. SIG improved 1RM strength more than CG (18% vs 10%, p<0.05). DISCUSSION AND CONCLUSIONS: Our major findings were that increased focus on upper-body sprint-intervals induced greater improvements in VO2max in DIA and upper-body 1RM strength than added focus on upper-body continuous endurance training. However, the significant improvements in DP peak speed and DP VO2peak, as well as in upper-body strength

within both groups indicate a general advantage of added focus on upper-body training among these female athletes. In addition, large individual variations in the adaptations were found in our data – indicating that an individual matching of such training to athletes might be beneficial.

Influence of pole lengths on o2-cost and 3d kinematics in double-poling: flat vs. uphill

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INTRODUCTION: Given the nature of double-poling (DP), where all propulsive forces are transferred through the poles, pole length is a parameter that could influence the skier's O2-cost and performance (1). Considering the reduced O2-cost with longer poles at flat terrain (1), together with the increasing use of DP on uphill terrain, the present study investigated how different pole lengths influence the O2-cost and kinematics in flat compared to uphill terrain. METHOD: Thirteen highly trained male cross-country skiers (self-selected [SS] pole length 84±1 % of body height) conducted two submaximal series, matched for external workload, with different incline and velocity on a rollerski treadmill: "flat" (1.7˚ and 4.5 m·s-1) and "uphill" (4.5˚ and 2.5 m·s-1). Each series included 4 trails (5 min, 3 min breaks) with the following pole lengths: SS-5 cm, SS, SS+5 cm and SS+10 cm. For each pole length, O2-cost, joint angles, pole angles, center of mass (COM) and cycle time were analyzed. RESULTS: On both flat and uphill, SS+10 cm had the lowest O2-cost compared to the other pole lengths (P<0.05; Effect size [ES]: 0.5-1.8). The relative changes in O2-cost between SS and the other pole lengths were larger in uphill compared with flat for both SS-5 cm (1.5%, ES: 0.8), SS+5 cm (1.3%, ES: 1.0) and SS+10 cm (1.9%, ES: 1.0), all P<0.05. SS+10 cm resulted in the smallest total displacement of COM on both flat and uphill. No significant differences in rate of perceived exhaustion, heart rate, pole angles or cycle time were found between pole lengths on either flat or uphill (P>0.05). DISCUSSION: This study imply that pole lengths at least up to ~ 90 % of body height reduce the skiers O2-cost during DP and that the advantage of longer pole lengths increases with steeper incline. Considering, that ~ 50% of total race time is used in uphill terrain (2,3), and that uphill performance correlates most strongly with overall performance (4), choice of pole lengths for the individual race profile seems important to optimize cross-country skiers performance. REFERENCES 1. Losnegard, T., Myklebust, H., Skattebo, H., Stadheim, H. K., Sandbakk, Ø., & Hallén, J. (2016). The influence of pole length on performance, O2-cost and kinematics in double poling. Int J Sports Physiol Perform (epub) 2. Andersson, E., Supej, M., Sandbakk, Ø., Sperlich, B., Stöggl, T., & Holmberg, H. C. (2010). Analysis of sprint cross-country skiing using a differential global navigation satellite system. Eur J Appl Physiol, 110:585-95. 3. Bolger, C., Kochbach, J., Hegge, A. M., & Sandbakk, Ø. (2015). Speed and heard rate profiles in skate and classical cross-country skiing competitions. Int J Sports Physiol Perform, 10:873-80. 4. Sandbakk Ø, Losnegard T, Skattebo Ø, Hegge AM, Tønnessen E, Kocbach J. (2016). Analysis of Classical Time-Trial Performance and Technique-Specific Physiological Determinants in Elite Female Cross Country Skiers. Front Physiol. 3;7:326.

Effects of acute nitrate supplementation during cross-country roller-skiing in normobaric hypoxia

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Introduction: Supplementation with beetroot juice (BR), which is rich in inorganic nitrate (NO3-), has received considerable attention due to its beneficial effects on several physiological functions. For example, BR has led to lowered resting blood pressure (BP) and a reduced oxygen (O2) cost during moderate-intensity exercise in healthy individuals, as well as improved maximal performance (1). Similar beneficial effects in athletes are less clear (2). The anaerobic reduction of NO3- to nitrite (NO2-) in the oral cavity increases the bioavailability of nitric oxide (NO), which is thought to explain the ergogenic effect of BR. Since NO is generally produced endogenously using O2 and multiple cofactors (3), any reduction in O2 availability would attenuate this NO-pathway. Therefore, BR supplementation is believed to have a more pronounced effect in hypoxia (H). The aim of the present study was to investigate the effects of BR supplementation in competitive cross-country skiers exercising in normoxia (N) and H. Methods: Using a randomised crossover design, eight competitive cross-country skiers (5 males: age 22 +/- 3 y, body mass 74 +/- 8 kg, VO2max 5.2 +/- 0.4 L/min; 3 females: age 21 +/- 1 y, body mass 63 +/- 6 kg, VO2max 3.7 +/- 0.5 L/min;) supplemented with a single dose of NO3- (ca 13 mmol) or placebo (PL) performed two, 6-min submaximal exercise bouts and a 1000-m time-trial (TT) in N and H (16.8% O2). All tests were conducted on roller skis at a 6-degree incline using the diagonal-stride technique. Resting BP, blood O2 saturation (SpO2), VO2, respiratory exchange ratio (RER), heart rate (HR), rating of perceived exertion (RPE), blood lactate (La-) and time to complete the 1000-m TT (TTtime) were measured. Results: Plasma NO3- and NO2- levels were significantly higher following BR compared to PL ($p < 0.001$). However, resting BP, submaximal exercise variables and TTtime were unaffected by supplementation ($p > 0.05$). The VO2max obtained during the TT was significantly lower with BR in N ($p < 0.05$, small effect size $d < 0.2$), but not H. Discussion: Previous studies have shown beneficial effects of NO3- supplementation among well-trained athletes (4). In addition, individuals showing no effects of NO3- supplementation in N have nevertheless shown improved exercise tolerance in H (5). These findings were not reproduced in the current study, with no improvements in submaximal VO2 or TTtime following BR supplementation in N or H. Conclusion: BR supplementation does not improve submaximal exercise economy or 1000-m TT performance in competitive cross-country skiers exercising in normoxic or hypoxic conditions. References: 1. Vanhatalo et al. 2010. Am J Physiol Regul Integr Comp Physiol. 299:R1121-31 2. Peacock et al. 2012. Med Sci Sports Exerc. 44:2213-19 3. Lundberg et al. 2015. Nat Rev Drug Discov. 14:623-41 4. Lansley et al. 2011. Med Sci Sports Exerc. 43:1125-31 5. Kelly et al. 2014. Am J Physiol Regul Integr Comp Physiol. 307:R920-30.

Should we be afraid of lactate? beneficial effects of elevated blood lactate concentration on high-intensity exercise performance

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Lactate (La) is termed a waste product, and still many believe this myth although it was shown that La is also an energy source, a gluconeogenetic precursor and an important regulator (Brooks 2009). The balance between La production and local and/or systemic La oxidation is elegantly described by the Lactate Shuttle Theory (LST) not only for exercising muscles (Brooks 2009) but also for the healthy (Figley 2011) and injured brain (Dienel 2014), different other tissues (Brooks 2009) and even solid tumours (Draoui et al. 2011). This presentation addresses a theoretical position on the influence of high-intensity pre-load lactate elevation like an intense warm-up program on subsequent high-intensity glycolytic exercise of non-pre-loaded muscles such as

alpine skiing. Somehow paradox effects as shown recently by our working group (Almer et al. 2015, Birnbaumer et al. 2016) can be explained by the LST (Brooks 2009). Athletes usually perform an intense warm-up program elevating La substantially (Bishop 2003), but for the main workout they try to start at low La. It is generally suggested that elevated La always impairs subsequent performance by reducing the anaerobic energy contribution and/or interfering with muscle contractile processes (Bishop 2001, 2003; Mujika et al. 2012) supported by studies showing that an elevated systemic La concentration inhibits the rate of lactate production in subsequent anaerobic work bouts (Bishop et al. 2001). This was also shown for a La increase by arm exercise that significantly decreased the rate of blood La accumulation in a subsequent cycle ergometer sprint by 50% (Bogdanis et al. 1994, Müller et al. 2015). Usually, lactate export from the working muscle follows an outward gradient at a low systemic La. In case of an elevated systemic La concentration the gradient is inverted which inhibits muscular La production and consequently favours oxidative energy production at the same workload. This fact may be beneficial for high-intensity workouts of 1-8 min duration as the shift to an enforced oxidative metabolism may maintain better coordinated muscle recruitment due to the reduced local muscle anaerobic energy contribution. Our working group applied this theoretical approach in various comparable situations in the laboratory (Almer et al. 2016; Bierbaumer 2016) and under field conditions for an alpine skiing specific box jump test which will be shown in detail by Sieder et al. (2016). Conclusion: Pre-elevated La levels by non-dominant muscle groups uniformly showed a significantly decreased net blood La increase of 30-50% in all experiments. This inhibition of La production did not reduce but in some cases even enhanced high-intensity exercise performance in dynamic workloads longer than 60 s and shifted metabolism to a more dominant oxidative one. We therefore suggest that this application of the La induction by non-dominant muscles may be used to enhance performance also in alpine skiing if applied properly. References at the authors [peter.hofmann@uni-graz.at].

Start performance in ski cross and snowboard cross: influence on race results and kinematic and kinetic analyses

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Although the disciplines Ski Cross (SX) and Snowboard Cross (SBX) have been part of the Olympic program since 2006, few research articles have been published and knowledge is mainly based on the experience of coaches and athletes. However, the performance at the start and in the following section seems to be crucial for performance (Argüelles et al., 2011). In a project, funded by the German Government, we analyzed the start performance and its impact on race results at the Olympic Winter Games 2014 along with kinematic and kinetic parameters of different movement strategies at the start in a ski hall. Methods: All starts of the 56 heats of the Winter Games 2014 (SX: 32 heats (16 female, 16 male), SBX: 24 (8 female, 16 male)) were video analyzed and the rankings of the athletes at 3 different measuring points (M1= right after start, M2=at first roller, M3=after first turn) were recorded. Additionally, start gate positions (SX: #1-#4, SBX: #1-#6, left to right) and in SX the number of pole pushes (0-4) were recorded. Kinematic and kinetic data were measured with the members of the German National Teams (SX: N=10, SBX: N=11) on two slope inclinations (flat/steep) and different start strategies with a 10-camera motion capture system (Simi Reality Motion Systems GmbH, Munich, Germany) with a sampling

rate of 100 Hz. Kinetic data were recorded with special handles (HJM Messtechnik GmbH, Kastl, Germany) at a sampling rate of 1 kHz. Results: SX: Regarding the total sample, there are significant (p<.05) correlations to qualify for the next round if the racer is ranked first or second on M1 (rs=.26), M2 (rs=.20) and M3 (rs=.43). For those who finished first or second, 42% choose start gate #2 and 55% of these successful racers used two pole pushes. SBX: In contrast to SX there is no significant correlation to qualify for the next round if the racer is ranked first or second on M1, but there are significant (p<.05) correlations on M2 (rs=.39) and on M3 (rs=.47). For those who finished first, second or third, 29% choose start gate #2. (For more results on kinematic and kinetic data see abstracts "Olvermann" and "Fruehschuetz"). Discussion: The results in SX support the findings of Argüelles et al. (2011) that it is very important to be in position one or two at the end of the first race section in order to finish first or second. This may also be stated for SBX with respective values. As correlations closer to the start gate are lower, it may be suggested, that this is the phase of sorting. At the investigated races of Sochi 2014 start gate 2 seemed to have been beneficial for later success. However, the starting performance appears to have crucial influence on the total performance, therefore the identification of relevant kinematic and kinetic parameter is important. Argüelles, J. et al. (2011). First section of the course performance as a critical aspect in skicross competition: 2010 Olympic Games & World Cup analysis. RevPortCienDesp 11 (2), 969- 972.

Start performance in ski cross: kinematic and kinetic analysis

Olvermann Matthias , Frühschütz Hannes , Goll Maren , Spitzenpfeil Peter , Huber Andreas

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INTRODUCTION: Ski cross is an aspiring discipline in winter sports and part of the Olympic Games since 2010. Argüelles et al. (2011) showed that the start-up phase is a very important part of the entire race, in which a preliminary decision about the race is made quite often. Therefore, the purpose of this study was to analyze the kinetics and kinematics of several different starting movements in ski cross and to identify the relevant parameters for a fast start. METHOD: Ten competitive athletes, five male and five female, of the German National Ski Team participated in this study. The athletes performed 12 starts, each in a steep and a flat starting area. The test was proceeded in a ski hall on artificial snow with a world-cup approved start gate. The starts were preset with four different motion specifications, the skiers performed in randomized order. A 10-camera motion capture system (Simi Reality Motion Systems GmbH, Munich, Germany) was used to measure the kinematic data with a sampling rate of 100 Hz. Kinetic data were recorded with special handles (HJM Messtechnik GmbH, Kastl, Germany) with a sampling rate of 1000Hz. Integrated two axial force transducers measured the forces from the pre-start phase to release. Additionally, a time measurement was made with light barriers for evaluating the starts based on the starting time. RESULTS: The maximum peak forces, related to bodyweight, was in average 12,47 ± 2,2 N/kg. This value correlates strongly to the starting time with a coefficient of r=0,91. For all different starting techniques, the pre-start force was in average 364 ±116 N. The maximum force rising was in average 3,23 ±0,98 N/ms, with a correlation coefficient of r=0,7 to the starting time. In the pre-start phase the height of the center of mass was in absolute terms 0,83 ±0,08m, related to the body size 0,52 ±0,08. As expected, the kinematic data show not much differences comparing left and right side while the starting movement. DISCUSSION/CONCLUSION: The measurements were accomplished in a realistic starting area with constant snow and air temperature. As expected, the start of the skiers is more effective,

if the athlete generates a higher force value during the pull phase. A good force transmission depends on body position and acceleration distance. With a larger number of athletes, the trends in the results might be more significant. REFERENCES Argüelles, J. et al. (2011). First section of the course performance as a critical aspect in skicross competition: 2010 Olympic Games & World Cup analysis. Portuguese Journal of Sport Sciences 11 (Suppl.2), 969- 972.

Start performance in snowboard cross: kinematic and kinetic analysis

Frühschütz Hannes , Olvermann Matthias , Goll Maren , Huber Andreas , Spitzenpfeil Peter

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Snowboard cross is an aspiring discipline in winter sports and part of the Olympic Games since 2006. Argüelles et al. (2011) showed that the start-up phase in ski cross is a very important part of the entire race, in which a preliminary decision about the race is made quite often. It can be assumed that this fact also applies to snowboard cross. Therefore, the purpose of this study was to analyze the kinetics and kinematics of several different starting movements in snowboard cross. METHOD: Eleven competitive athletes, nine male and two female, of the German national snowboard cross team participated in this study. The athletes performed 15 starts, each in a steep and a flat starting area. The test was proceeded in a ski hall on artificial snow with a world-cup approved start gate. The starts were preset with five different motion specifications, performed in randomized order. A 10-camera motion capture system (Simi Reality Motion Systems GmbH, Munich, Germany) was used to measure kinematic data with a sampling rate of 100 Hz. Kinetic data were recorded with special handles (HJM Messtechnik GmbH, Kastl, Germany) with a sampling rate of 1000Hz. Integrated two axial force transducers measured the forces from the pre-start phase to release. Additional, time measurement was made with light barriers for evaluating the starts based on the starting time. Because of the non-symmetrical starting movement, all parameters referred to a body side were subdivided in dominant and non-dominant. RESULTS: Over all data, the average maximum force and the average maximum horizontal force measured was 894.8 N (±148.7 N) and 860.0 N (±147.2 N) respectively. Especially for the flat starting area, the maximum horizontal force shows a high correlation ($r = 0.85$) concerning the starting time. Without separating the starting area, the correlation coefficient for the maximum horizontal force is still high with $r = 0.80$. Furthermore, the characteristic of preloading is different in the five given motion specifications. The kinematic parameters show a trend to correlations of body position and starting time. Results for differences in kinematic between the dominant and non-dominant body side are in progress. DISCUSSION: The measurements were accomplished in a realistic surrounding with constant snow and air temperature. The results show that higher maximum horizontal forces and their quicker increase encourage a shorter starting time. A good force transmission depends on body position and acceleration distance. The small number of participants doesn't allow the use of established statistical methods in the field of variances analysis. Thus, it's not possible to present significant results concerning the mentioned parameters. REFERENCES Argüelles, J. et al. (2011). First section of the course performance as a critical aspect in skicross competition: 2010 Olympic Games & World Cup analysis. Portuguese Journal of Sport Sciences 11 (Suppl.2), 969- 972

Visual inspection of skiing course and terrain using virtual and augmented environment

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INTRODUCTION: The study of visual perception and physical actions integration constitute fundamental scientific interest (Heinrich Bülthoff, 2008). This work relies on methods well described in (Aleshin et al., 2012). The significant miniaturization and mobility of modern 3D virtual environment (VE) devices make the appropriate equipment easy to use directly on a ski course. The virtual visual inspection of a course and a difficult relief with the use of mobile VE devices is actual for professional sports, freeride, extreme skiing. METHOD: We use mobile devices based on smartphones with geo-linking to make a model of skier movement on a slope. 3D models of the used locations are obtained from the available databases and could also be obtained with unmanned drones. The training system described in (Aleshin et al., 2009) is used to make additional calibration and estimate the effectiveness of the used technology. RESULTS: The degree of the courses and relief uptake using the virtual skiing is shown. The problem of virtual/augmented reality and physical objects combination is considered. DISCUSSION: The progress of equipment allows to increase the efficiency of the methods previously announced in (Aleshin et al., 2015). CONCLUSION: The proposed technology could significantly enhance the security of skiing course in the hard viewed relief and bad sight conditions. REFERENCES: Heinrich Bülthoff, Going beyond vision: multisensory integration for perception and action, // ICVS 2008,Santorini, May 12 2008 Vladimir Aleshin, Stanislav Klimenko, Andrey Klimenko Alexander Bobkov, Dimitrij Novgorodtsev (2015), Virtual Environment Systems For A 3d Perception Research Of The Ski Course, // Proc. of the 6th ICSS 2013, St. Christoph, Austria, 59-68. Vladimir Aleshin, Stanislav Klimenko, Alexander Bobkov, Dimitrij Novgorodtsev (2012), A Visual 3d Perception Of The Ski Course And Skiing Results, // Proc. of the 5th ICSS 2010, St. Christoph, Austria, 59-68. Vladimir Aleshin, Stanislav Klimenko, Mikhail Manuilov, Leonid Melnikov (2009), Alpine Skiing And Snowboarding System Using Induced Virtual Environment, // Proc. of the 4th ICSS 2007, St. Christoph, Austria, 137-144. Ashley Colley, Jani Väyrynen, and Jonna Häkkilä. (2015). Skiing in a blended virtuality: an in-the-wild experiment. // Proceedings of the 19th International Academic Mindtrek Conference (AcademicMindTrek'15). ACM, New York, NY, USA, 89-91. dx.doi.org/10.1145/2818187.2818288.

Simulated ski specific shocks - impact on force, time and knee angle parameters: a pilot study

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INTRODUCTION: After the challenging jump “Hausbergkante” in Kitzbühel’s famous Hahnenkamm downhill, racers must navigate the bumpy “Traverse”. When skiing bumpy sections or when a ski suddenly hits a hole or a rut, racers are exposed to very high external forces with short unexpected eccentric (CEC) or concentric (ECE) shocks. CEC represents a slow concentric leg extension with a fast eccentric shock (simulating a bump) and ECE is a slow

eccentric leg extension with a fast concentric shock (simulating a hole). Therefore, the aim of the study was twofold: first to find an adequate way to generate CEC and ECE shocks, and second to compare these shocks in terms of force, time and knee angle parameters. METHODS: Eleven strength-trained men performed ten unilateral maximal concentric and eccentric leg extensions (v=0.2m/s) with CEC and ECE shocks (v=2.0m/s) on the self-developed evolution training device. Leg extension force was recorded with a 3-dimensional force plate. Range of motion was set at knee angles 80° to 140°. The five best trials of the ten repetitions of each of the two series were collected. Force values (Fmax, Fmin), rate of force development (RFD) and rate of force lost (RFL) together with the knee angle and time parameters were analyzed. Pearson correlations assessed selected relationships. The level of significance was set at $p<0.05$. RESULTS: CEC shock: A mean FmaxCEC of 1440±192N at a knee angle of 105±4° was calculated. FmaxCEC occurred 75±4ms after the onset of the CEC shock with a mean RFDCEC of 2.5±0.3N/ms. FminCEC of 1108±197N was detected 127±47ms after the end of the CEC shock. ECE shock: An FmaxECE of 1733±273N with a knee angle 115±4° appeared 166±41ms after the end of the ECE shock with a mean RFDECE of 1.8±0.6N/ms. FminECE (1324±216N with a mean RFLECE of -4.8±0.7N/ms) occurred 67±11ms after the ECE shock release. The correlation ($r=0.85$, $p<0.001$) between FmaxECE und RFDECE was highly significant. There was no significant correlation ($r=0.20$, $p=0.55$) between FmaxCEC and RFDCEC. DISCUSSION: The evolution training device creates shocks of varied speed, structure and duration. The pilot study showed that CEC or ECE shocks which simulate bumps or ruts in ski racing affect Fmax, Fmin, RFD and RFL differently. The significant correlation between FmaxECE and RFDECE showed that Fmax may be the main factor during a SSC in which FmaxECE occurred approximately 170ms after the end of the shock. In contrast, there was no significant correlation between these values during the CEC shock, in which FmaxCEC was reached only 75ms after the start of the shock. Further research is necessary to analyze the underlying mechanisms in such highly dynamic contractions (Maffiuletti et al., 2016). REFERENCES: Maffiuletti, N. A., Aagaard, P., Blazevich, A. J., Folland, J., Tillin, N., & Duchateau, J. (2016). Rate of force development: physiological and methodological considerations European Journal of Applied Physiology, doi: 10.1007/s00421-016-3346-6.

Associated Pathology and Limb Asymmetry in ACL Reconstructed Elite Alpine Racers

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Introduction: Associated pathology (AP) affects outcome after anterior cruciate ligament (ACL) tears and sport-specific injury patterns exist (Bisson et al., 2013; Granan et al., 2013). Little is known about AP in elite skiers with ACL injuries or the time-course of recovery. Using a retrospective design, we evaluated AP at primary ACL reconstruction (ACLR), the injury progression and recovery of functional symmetry in ski racers. Methods: Primary ACLR operative reports (n=28) and subsequent operative reports (n=20) were reviewed to evaluate AP and injury progression. Seventeen skiers also were tested for functional (between-limb) asymmetry in bilateral vertical jumping between 138 and 4444 days following the primary ACLR. Asymmetry indices (AI) were calculated over discrete jump phases using dual force plate analysis (Jordan et al., 2015). The effect of time since ACLR on AI was evaluated. Results: Isolated ACL tears (18%) occurred less frequently compared to knees with AP (82%). Chondral lesions were found in 54%

of knees and 73% were in the lateral compartment. ACL revision occurred in 28% of knees and 22% had a contralateral ACL tear. After primary ACLR, 40% of meniscal tears and 80% of chondral lesions had worsened. Time following the primary ACLR explained between 26% and 54% of the variance in AI. Discussion: More AP was suffered in these elite skiers compared to other athlete populations (Granan et al., 2013) and the general population (Bisson et al., 2013). ACL re-injury prevalence was similar to other reports (Pujol et al., 2007). It took nearly 2 years for functional symmetry to reach levels comparable to elite skiers without ACLR (Jordan et al., 2015). Conclusion: Elite skiers suffer traumatic knee injuries and recovery following injury is delayed. Future research is required to confirm the findings of this investigation, and evaluate the relationship between AP, re-injury, recovery and knee joint health in ACLR skiers. References: Bisson, L. J., Kluczynski, M. a, Hagstrom, L. S., & Marzo, J. M. (2013). A Prospective Study of the Association Between Bone Contusion and Intra-articular Injuries Associated With Acute Anterior Cruciate Ligament Tear. The American Journal of Sports Medicine, 1–7. Granan, L., & Inacio, M. (2013). Sport-specific injury pattern recorded during anterior cruciate ligament reconstruction. The American Journal of Sports Medicine, 41(12), 2814–2818. Jordan, M. J., Aagaard, P., & Herzog, W. (2015). Lower limb asymmetry in mechanical muscle function: A comparison between ski racers with and without ACL reconstruction. Scandinavian Journal of Medicine & Science in Sports, 25(3), e301–e309. Pujol, N., Philippe, M., Blanchi, R., Chambat, P., & Santy, C. O. (2005). The Incidence of Anterior Cruciate Ligament Injuries Among Competitive Alpine Skiers A 25-year Investigation. The American Journal of Sports Medicine, 35(7), 1070–1074.

Microvascular oxygen extraction during competetive alpine skiing with regard to loaded and unloaded phases

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INTRODUCTION: Competitive elite alpine skiing imposes high metabolic demands to both, aerobic and anaerobic systems. Amount and speed of oxygen uptake kinetics are dependent on microvascular oxygen supply and extraction whereas intramuscular pressure by high external loads and posture can impair local perfusion. The current study aims to examine the microvascular oxygen extraction of relevant musculature during race conditions and to distinguish between loaded and unloaded phases during the race. METHOD: Six male elite skiers (19 ± 2.5 yrs) participated in this study. During world cup race conditions (Foreruns of downhill race [DH] and Super-G [SG] in Garmisch-Partenkirchen, GER), relative changes in deoxygenated haemoglobin (ΔHHb) was monitored using near-infrared spectroscopy (NIRS) of the right vastus lateralis muscle. All six subjects completed a DH, whereas two of the subjects completed a SG race additionally. Furthermore, maximum deoxygenation was obtained using the artieral occlusion method in static, neutral skiing position in order to normalize ΔHHb during race conditions. To assign the NIRS data to a certain section of the race course, GPS data was recorded simultaneously. Mean muscle deoxygenation was calculated between 25%-75% of the run. RESULTS: Normalized ΔHHb was 41±21% during DH. The two subjects, that also completed a SG showed similar or higher ΔHHb during SG compared to DH conditions (+9% & +23%). The time-courses of ΔHHb reflected the shape of the race course: during leftward turns (right leg outside), a reduced level of ΔHHb was observed while there was an increased level during rightward turns (right leg inside) (53±24% vs. 64±28%, difference +11%). This difference was equal or higher during SG compared to DH conditions (+1% & +16%). DISCUSSION: Albeit the

observed values of normalized ΔHHb demonstrate a considerable high oxygen extraction during race conditions, the results clearly show that even during skiing with high external loads like WC races, the m. vastus lateralis is not occluded, presumably because of the change of external loading by the changing of inner and outer leg. A reduced level of ΔHHb during skiing at a comparable effort is generally associated with an improved matching of microvascular oxygen supply and extraction, which in turn has been shown to be linked to the speeding of oxygen uptake kinetics during exercise on-transitions. As WC downhill races represent high intensity exercise that is maintained for a considerable period of time, beside anaerobic pathways, aerobic processes are of high relevance for skiing performance. Subjects with faster aerobic kinetics can benefit from a more economical use of energy stores by reduced anaerobic contribution. CONCLUSION: To examine oxygen uptake kinetics and the matching of microvascular oxygen delivery and supply, the combined assessment of gas exchange measurements and NIRS should be applied.

Redistribution of Lower Extremity Joint Moments during Alpine Skiing

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INTRODUCTION: The sagittal plane knee joint moment is a surrogate measure of knee loading. Changes in the magnitude of this moment with a specific intervention are often attributed to alterations in the magnitude of the ground reaction force (GRF) or the length of the lever arm between the GRF and knee joint center. The product of these two variables comprise the simplified lever-arm method of computing knee joint moments. This method becomes functionally meaningful to alpine skiing research when calculations are made with respect to the load bearing axis (LBA) of the lower limbs. Coordinated hip, knee, and ankle motions during a ski turn influence the orientation of the LBA consequently altering the distribution of lower extremity joint moments. The purpose of this study was to apply the lever-arm method of measuring joint moments to determine the effects of a wearable, knee loading intervention device during alpine skiing. METHODS: Three male and 3 female ski racers (FIS Slalom ranking: 23.5 ± 17.8) performed 4 to 6 trials of simulated slalom racing on a water-injected course with a mean slope inclination of 20°. The gates were 12 m apart down the fall line and offset 3 m. The racers were instrumented with foot pressure insoles, 13 wireless inertial measurement units and a global positioning sensor. The data were combined with anthropometric models to measure the kinematics and kinetics of the racer's dominant leg during 9 consecutive double turns. Each participant performed with their own equipment while either wearing a knee loading intervention device consisting of directional compression (DCP) tights (Opedix LLC, USA) or standard compression (SCP) tights (2XU, USA). Average turn velocity and select kinematic and kinetic variables were contrasted between conditions with repeated measures ANOVA. RESULTS and DISCUSSION: Average turning velocity was not different between compression conditions ($p>.05$). Maximum GRF, average knee joint moment arm length, peak knee joint moment and extensor angular impulse was 6%, 2%, 6% and 14% lower for the DCP condition (all $p<.05$), whereas the average AP FAP was 3% greater ($p<.05$). Reduced knee joint moments but similar average turning velocities during the DCP condition indicate that the intervention device

induced a shift in function between muscle groups and reduced the demand on the knee extensors. CONCLUSION: A simple intervention device was found to exploit the flexibility inherent in the human neuromuscular system to redistribute lower extremity joint moments and reduce knee joint loading during alpine skiing.

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Becadas por el Programa Mujer y Nieve SPAINSNOW