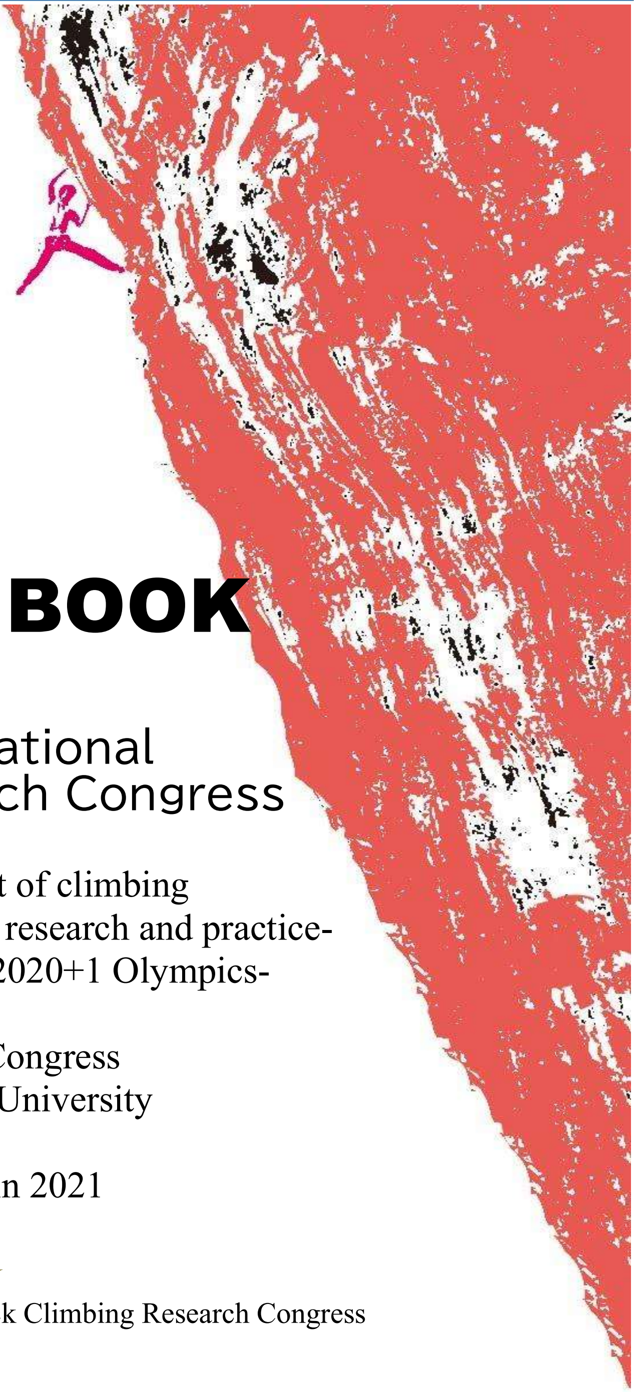
International Rock Climbing Research Association

5th International Rock Climbing Research Congress in Tokyo



CONGRESS BOOK

of the 5th International Rock Climbing Research Congress

For further development of climbing
-Bridging the gap between climbing research and practice-
-Looking back on Tokyo 2020+1 Olympics-

Head quarters of the Congress
Izumi Campus of Meiji University
Date
11th–14th November in 2021

ORGANISED BY
Executive Committee of the 5th International Rock Climbing Research Congress

Welcome from the President of IRCRA

On behalf of the IRCRA executive board, it is my great pleasure to welcome you to the 5th IRCRA Congress, being hosted in Tokyo, Japan. It has been three long years from the last IRCRA Congress due to the world pandemic, so it means we are even more excited to finally running this wonderful event.

Since the first edition in 2011 by Nick Draper, IRCRA has established a solid international reputation as the world's leading research climbing Conference. We enjoyed in Pontresina (Switzerland), Telluride (CO, USA), Chamonix (France), and finally Tokyo (Japan). However, Tokyo will be online this time. We were excited to be there after Climbing Debut at the Olympic Games. Nevertheless, everything changed due to the COVID-19 pandemic. Nowadays, the 5th IRCRA online Tokyo Congress will be highlighted our greater adaptation capacity and our enthusiasm to carry out this congress despite all the difficulties caused by the COVID-19.

I really hope you enjoyed the 5th IRCRA Congress. It is always an occasion to discuss the latest findings and research efforts in our climbing field as well as new approaches from different perspectives, and possibilities for our athletes. In other words, to bridge the gap between climbing research and practice. Remember that IRCRA provides a tremendous opportunity to climbing practitioners and researchers working in the fields related to rock climbing to meet their peers, establish productive collaborations, exchange ideas, advance the state of the art and make a positive impact on climbing society and the environment.

Thank you, Shinji Mizumura!!. As an organization, we are very grateful to you and the Organizing committee for taking the lead with the current COVID-19 circumstances and having finally this wonderful 4-days experience. Thanks Taylor Reed for being my right hand during the process. Thanks to all the Scientific committee to accepted and reviewing with such rigor in a very short time. Finally, and most important, thank you to all the coauthors and participants to be part and believe in this 5th IRCRA Congress.

Special words to Pierre Legreneur for being involved with so much energy at IRCRA, for bring ever more rigor to this panel and, of course, for believing in me to be the President for the next coming years. I hope to be carry out this charge at least as you did. I am really grateful, I miss you and I hope to have you close very soon.

Finally, I hope this Congress experience will leave you longing for your next IRCRA event, which will be our 6th Congress to be hosted in Cadiz, Spain in 2023.

Welcome to the 2021 International Rock Climbing Research Association Congress!

President IRCRA: Vanesa España Romero (Cadiz University, SPAIN)

Welcome from the 5th Congress Organizer

On behalf of the local organizer, I would like to thank all the people who participated in the 5th International Rock Climbing Research Association (IRCRA) Congress. It is held online, but welcome to Meiji University, Tokyo, Japan three months after the Tokyo 2020 Olympic Games.

It is a great pleasure for me to welcome you for four days to bridge the gap between climbing research and practice. Thanks to much advice and great help from Nick Draper, Pierre Legreneur, Vanesa España-Romero, and Taylor Reed, the Organizers were able to reach the holding of the 5th IRCRA Congress. Without their help, I can say it never be happened. I appreciate them.

The organizing committee and Meiji University have been working for almost two years to welcome you to the Izumi Campus of Meiji University, Tokyo, JAPAN. With the spread of COVID-19 infection, although we have not had an onsite Congress in Tokyo, we can have an online meeting. I am delighted to hold this Congress.

Please learn and enjoy the contents of this Congress through twenty-nine (29) live, ten (10) video peer-reviewed presentations, four (4) plenary lectures, three (3) special reports from Japanese legendary climbers, and four (4) reports from Olympic National coaches, eight (8) breakout sessions to communicate with coffee or some drinks.

Finally, I hope all the participants will have a wellness life with Rock climbing.

5th Congress Organizer: Shinji Mizumura (Meiji University, JAPAN)

ORGANISATION

Executive board of the IRCRA

President : Vanesa ESPAÑA-ROMERO (Spain)
Treasurer: Ludovic SEIFERT (France)
Secretary: Taylor REED (USA)

Congress Organiser: Executive Committee of the 5th IRCRA Congress
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Publishing and Public Relation Manager : Taylor REED (USA)
Venue Manager : Masako HARIGAYA (Meiji University, Japan)
Vice-venue Managers : Rina MIYAWAKI (Meiji University, Japan)
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Simon Fryer
Volker Schöffl
Xavier Sanchez

SPONSORS

International Federation of Sport Climbing (IFSC, https://www.ifsc-climbing.org/)

Kailas (https://www.kailasgear.com/)

Luxov (http://www.luxov-connect.com/)

Meiji University (https://www.meiji.ac.jp/cip/english/)

Japan Mountaineering and Sport Climbing Association (JMSCA, https://www.jma-climbing.org/)

Japan University Sport Climbing Association (JUSCA, https://www.jusca-climbing.org/english/)

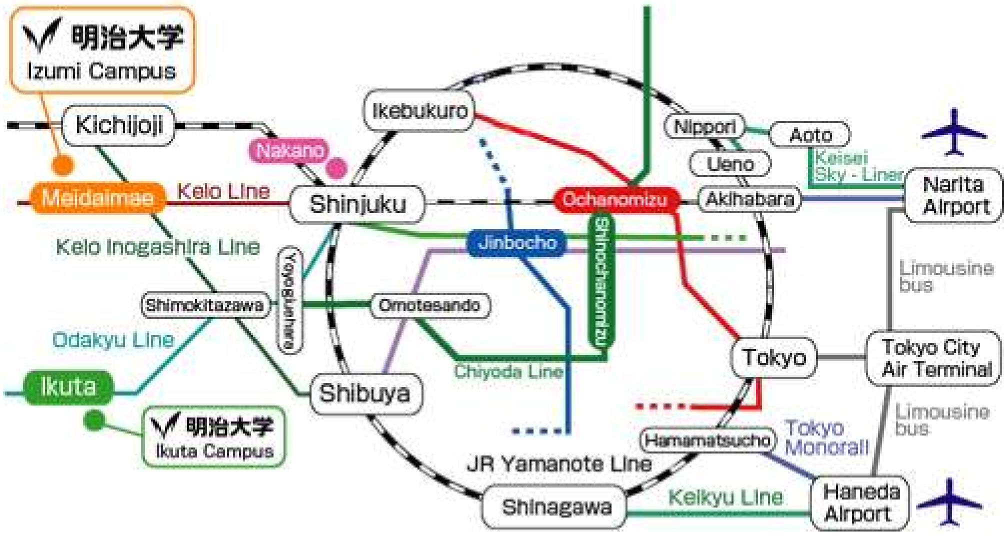
ONLINE CONGRESS VENUE

Hilton Tokyo (You can participate from anywhere by Zoom meeting)

STARTING TIME OF THE CONGRESS

Due to wide time differences among Europe, Pan-America, Oceania, and Asia, the Executive Committee has set the starting time as 20:00 in Japan time (12:00 in CET). Please understand that.

MAP&ACCESS



HEADQURTERS : Izumi campus of MEIJI University The 3rd and 4th floor of the Media Building
NEAREST STATION: KEIO LINE MEIDAIMAE
ADDRESS : 1-9-1 Eihuku Suginami-ku Tokyo, JAPAN

TRAVEL DETAILS

By air plane:

Tokyo International Airport (Haneda Airport) and Narita International Airport (Narita Airport) are the nearest International airport from the venue and the place to stay.

WHERE YOU SHOULD STAY?
Shinjuku is strongly recommended staying just before and during the Congress. It takes about 10 minutes from Shinjuku station to the Congress venue (Media Building of Izumi Campus of Meiji University); 5-6 minutes by KEIO LINE from KEIO Shinjuku station to MEIDAI-MAE station and 3 minutes by walk from the MEIDAI-MAE station to the venue.

HOW TO GET TO SHINJUKU:
BY BUS:
You can take a shuttle bus from Narita airport to Shinjuku (Basta Shinjuku). From Haneda airport, you can take a bus bound for

Timetable1 (from Narita to Shinjuku Expressway Bus Terminal):
https://www.limousinebus.co.jp/en/areas/bus_stop/nrt/shinjuku/dep/279/

Timetable2 (from Haneda to Shinjuku Expressway Bus Terminal):
https://www.limousinebus.co.jp/en/areas/bus_stop/hnd/shinjuku/dep/279/4

BY TRAIN:
You can use "HyperDia" which offers
the route and the timetable of the railway and the aviation of Japan:
http://www.hyperdia.com/en/

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LOOKING BACK TO TOKYO2020

LIVE PRESENTATIONS

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Day 4 - Session 2

VIDEO PRESENTATIONS

DAY 1 (11TH NOVEMBER)

INVITED LECTURES

A Welcome Remark from President of Meiji University

Creating a peaceful world through the exchange of diverse ideas

Kosaku Dairokuno,President, Meiji University

Welcome to Meiji University online.

As president of Meiji University, I would like to thank you for your attendance at the 5th Congress of International Rock Climbing Research Association (IRCRA) on our campus for the next four days. This Congress is jointly hosted by the International Federation of Sports Climbing, Japan Mountaineering and Sports Climbing Association, the Japan University Sport Climbing Ass ociation, and Meiji University, under the auspices of KAILAS and LUXOV.

Since December 2019, Japan, alongside the global community, has faced unprecedented challenges arising from the COVID-19 pandemic. At Meiji University, we moved most of our classes online so that our students could continue to make the best use of their learning opportunities. We also prepared an enhanced set of safe distancing measures for the benefit of campus facilities in order to reduce risks during this critical period. These are part of Meiji University's efforts to ensure the continued provision of quality education for our students while being firmly committed to the safety and well-being of the university community. We have started cautiously moving back to normalcy because of a dramatic decline in the number of newly infected cases in recent months (from 25,856 a day on Aug. 25 to 292 a day on Oct. 29).

Today, universities are expected to play an important role in confronting the problems that threaten the survival and dignity of human beings. They are also expected to develop technologies, systems, ideas, and the wisdom to solve these serious problems that human beings now face. With "Rights and Liberty," "Independence and Self-government" as its guiding principles, we believe that our university must become a base for a research and education hub aiming to create a peaceful society in which everybody can see that life is worth living. I would like everybody to disregard the conventional rules, consider critically the history of civilization that has brought us such unprecedented wealth, and then tackle the global issues that now threaten the fabric of modern society.

In order to achieve these objectives, I firmly believe that the exchange of ideas among people with diverse values and cultural backgrounds is the key to creating a shared understanding and making a peaceful society and a world based on it. As a global hub of research and education, Meiji University is determined to accelerate the global exchange of students, faculty members, and professionals in every possible way, even in this challenging time. I hope that the 5th Congress of International Rock Climbing Research Association (IRCRA) will be a successful one creating a shared understanding and goals for the future.

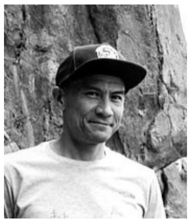
Now I close by wishing you continued success and happiness. Thank you.

Plenary lecture 1

Changes in medical issues in sport climbing since its inclusion into the Olympic Games by Schöffl Volker

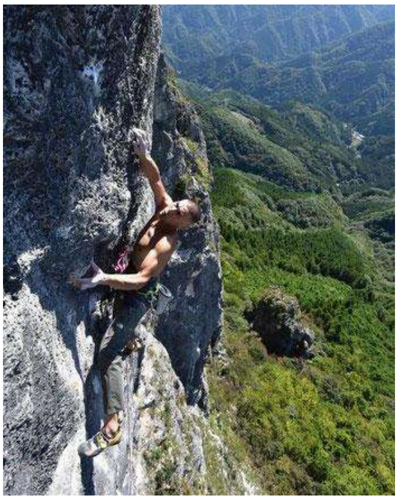
With the inclusion of climbing into the Olympic program also a new competition mode was inaugurated, the Olympic combined. What used to be specialists in bouldering, speed or lead climbing now needed to become all-rounders for the Olympics. This increased overall training volume and load onto the climbers. Since the announcement of climbing to become an Olympic sport in 2017 we performed a single-center injury surveillance in 436 climbing patients with a total number of 633 independent climbing-related injuries or complaints. 77.1% of the injuries affected the upper extremities, 17.7% the lower and 5.2% other body regions. Injury severity was overall low. The most frequent injuries overall were: finger pulley injuries and finger tenosynovitis. Epiphyseal growth plate injuries and lumbrical injuries increased. Acute injuries were detected in 43.9% of all injuries and chronic overuse injuries in 56.1%. Bouldering accidents were the leading cause of acute injuries (60.4%). Among shoulder injuries, superior labral lesion tears from anterior to posterior (SLAP) represented the leading diagnosis (29.8%). In comparison to our two prior study populations (1998-2001 and 2009-2012), we found nowadays: 1) an overall decrease in upper extremity injuries, 2) an increase of lower extremity injuries, 3) a constant decrease in finger pulley injuries and epicondylitis, 4) a rise of knee injuries and shoulder dislocations, 5) an increase in adolescents finger growth plate injuries.

Special Report from Japan 1



Attempt to inherit Climbing culture and Climbing areas in a better way by HIRAYAMA Yuji (Base Camp LTD)

It has been 37 years since I started climbing, and I have climbed in various climbing areas around the world. Therefore, I often went on climbing tours in Japan and overseas with various goals, but in this corona disaster, activities increased mainly in the local area of Japan. There, I witnessed various situations in the climbing areas of Japan. The area that was climbed 30 years ago can no longer be climbed at all, there is an area that you want to climb, but you cannot move forward for various reasons, you are wondering about the old route, or you feel uncomfortable about the grade. I want the climbing area to survive from the past to the future, and I want it to be inherited well. Witnessing such a situation, revitalizing the climbing area in my hometown, communicating with local governments and climbers for further development, and being able to inherit the climbing culture and climbing area from the past to the future in a better way. I'm trying. The Rocks are a property for climbers. I would like to talk about our efforts to develop the increasingly popular climbing in a better direction without losing the essential part of climbing.



DAY 2 (12TH NOVEMBER)

Plenary lecture 2

Physiology of climbing: building the way to high performance by C-HIPPER study by Dra. Vanesa España Romero

[1]MOVE-IT Research group and Department of Physical Education, Faculty of Education Sciences University of Cádiz, Cádiz, Spain.

[2]Biomedical Research and Innovation Institute of Cádiz (INiBICA) Research Unit, Puerta del Mar University Hospital University of Cádiz, Spain

The popularity of the sport climbing as a recreational activity and as a training mode for rock climbing has been increasing over the last years. Due to such increase in participation, interest in improving personal climbing performance through specific practice and training is growing.

The lecture will be of interest to researchers and applied scientists as well as sport practitioners. It will also be of relevance to anyone interested in the field of physiology and sport performance as well as sport and health applications. Specifically, It will be examined the physiological adaptation in climbers observed by the C-HIPPER project (High Performance Climbing). The C-HIPPER project is an international rock climbing research project that came about following the 2nd IRCRA Congress in Pontresina (Switzerland). The Congress provided an excellent opportunity for like-minded researchers to come together and form such collaborations.

The main purpose of C-HIPPER project was to improve our knowledge in physiological and psychological aspects related to high climbing performance in a group of climbers of different abilities, connecting professionals from different disciplines.

Sports climbers from different cities of Spain were assessed at two different waves in Granada (n=38 in 2015) and Cadiz (n=28 in 2019). Some of the main physiological measurement assessed were i) socio-demographic characteristics; ii) body composition by Dual-energy X-ray absorptiometry, Digital anthropometry via three-dimensional optical scanning and Biompedancie; iii) maximal oxygen uptake in incremental treadwall and treadmill test using K4b2; iv) muscle tissue oxygenation kinetics and blood flow responses during rock climbing and recovery time using near infrared spectroscopy; v) Infrared thermography pre-post incremental treadwall test by flir E-60 camera; vi) finger muscle strength on a crimp pre-post incremental treadwall test; vii) forearm volume pre-post incremental treadwall test; viii) electromyography (EMG), muscle tissue oxygenation kinetics and blood flow responses performing an intermittent isometric contractions test (7":3") on both, slope and crimp grip; and ix) dietary patterns. Deeply, psychological measurements were also assessed: i) cerebral blow flow responses during psychological tasks and incremental treadwall test using near infrared spectroscopy; ii) attentional control using Vienna test system; iii) Emotional intelligence as ability using Mayer Salovey Caruso Emotional Intelligence Test and as a trait using Schutte Self-Report Emotional Intelligence Test; iv) working memory using e-corsy task; v) Inhibitory control using go/non go task.

The findings of the C-HIPPER project may help to develop climbing specific psychological and physiological performance measures that will provide both the athlete and coach with information in order to monitor performance and help optimize individuals training regimes. The findings will also serve as a scientific platform for interventional studies. More details about the C-HIPPER project will be discussed at the 5th IRCRA Congress.

Special Report from Japan 2

Climbing Enlightenment by AMMA Sachi (Professional Climber)

I am very pleased to be able to present a subject very close to my heart as a research topic at the 5th IRCRA Congress. I am very grateful to Professor Mizumura of Meiji University and all the other individuals who helped to provide me with this valuable opportunity.

First, I would like to introduce myself. My name is Sachi Amma, and I am 32 years old. I attended Waseda University but dropped out partway through. I am a professional climber, and I specialize in both sport climbing and trad climbing. I have been climbing for 19 years, and I won the World Cup lead overall title in 2012 and 2013. I stopped competing in 2016, and I have focused on outdoor rock climbing since then. I have also been engaged in an active process of self-inquiry since 2014.

Today, I'll be speaking on the theme of "climbing enlightenment." After winning the climbing World Cup in 2013, I turned my focus towards outdoor rock climbing, and in the six years since 2016, I have also regularly practiced meditation. In my life, my meditation and climbing have come to continually reinforce one another, and I have come to understand that this is a process that can eventually lead to enlightenment.

The term "climbing enlightenment" is a concept that I came up with myself. It was born from the insights I have gained as I look back on what I have learned during my climbing life. Today, I will talk about the "awareness" I have gained, the mutual relationship I have discovered between climbing and meditation, and the enlightenment that this can lead to.

In Japanese, "enlightenment" can be expressed using the word "komyo," which indicates a light, or a state of awakening or comprehension. When used as a Buddhist term, "komyo" describes a light that emanates from the mind and body of a Buddha or Bodhisattva, a light that symbolizes mercy and wisdom. In Buddhist and yoga teachings, there are several stages of awakening. Smaller "awarenesses" lead to a fuller awakening, culminating in what can be described as "a state of infinite effortlessness in the present moment." To express this in a more understandable way, this is a state when one is filled with wisdom, innocence and love, completely freed from personal attachments, and utterly relaxed in the present moment and place. And meditation is one path to such enlightenment.

I discovered climbing when I was 12 years old, and it captivated me from the very beginning. I immediately devoted myself – heart and soul – to climbing, and when I look back on that time, especially after having spent so many years engaged in climbing and meditation, I see my younger self experiencing the joy of the moment in its purest possible form.

I couldn't get enough of climbing, and I soon managed to start winning and placing in climbing competitions. I won the World Youth Competition when I was a high school student, and I also advanced to the final round of the World Cup. It was just a natural next step to aim towards winning the World Cup series title. I dedicated 10 years of my life to competitions, and I learned many things during that time, but the greatest gift that I gained was an understanding of how to achieve my goals. There were three components to this:

1: Setting achievable goals
2: Clarifying what was necessary to achieve these goals
3: Refusing to give up until the goal had been met

Understanding this helped me to make the choices and employ the practices that allowed me to cultivate a greater sense of self-reliance. And along with my deliberate approach of achieving many small goals, I also learned that it is important to believe in things that you feel confident about for no reason, even if they are ambitious goals that seem infinitely far away.

During the part of my life that I dedicated to competing, there was also something that I lost. Winning competitions was my highest priority, so taking the time and cultivating the senses to appreciate the present moment were things I had to sacrifice. For example, enjoying the beauty of the four seasons, eating what I really wanted to eat, and doing the things that I really wanted to do – these were all things that had to be pushed aside for the time being.

I won the World Cup in 2012 and 2013, and I can still vividly remember what it felt like to climb those final routes. And when I stood on the podium, I had this remarkable sensation of seeing myself from a bird's-eye perspective, and feeling a quiet and tranquil sense of happiness. But the same time, I also felt inside myself a complicated mixture of feelings – a determination to make my life a happy one, a pure and simple desire to win competitions, and a strong craving for self-acceptance. This made me unable to simply feel joy at my victory, and I felt a painful struggle within myself.

Practicing meditation not only helped me to objectively understand my confused state of mind and emotional suffering, but it also helped to release me from this state and once again become capable of accepting my climbing experience in its entirety. Through meditation, I gained a higher quality of awareness, an ability to feel and appreciate the present moment, and an appreciation for silence and relaxation, and all of these things reinforced my climbing. The mutually reinforcing relationship between meditation and climbing helps to deepen both of these experiences. For young climbing competitors, this is a process that can help them to preserve their psychological health while also helping them to achieve their goals, and it can also help ordinary climbers maintain a profound joy in their climbing, regardless of their level or climbing style.

At around the age of 9, I remember that I began to develop a strong interest in scenes of religious training at temples, and I also became interested in undergoing such training myself. I'm not sure why, but in my mind, I imagined myself with other boys my age, receiving instruction in an atmosphere that was relaxed and compassionate. I'm not sure where this image naturally sprang from, but if I continue my practice of meditation, maybe someday I will discover the answer to this. I still have a strong desire to understand what human existence is all about, and this is something I pursue through my meditation and climbing.

I began my practice of meditation in 2016. I am the type of person who learns through experience, so, to achieve a more authentic and complete experience of meditation, I traveled to meet people who were said to have actually been enlightened. I met Tibetan high priests, Indian saints, Nepalese teachers of meditation, Italian tantra masters, Indian yogis, and British and Japanese meditation practitioners. Each of these individuals had a completely different quality of enlightenment, and they possessed a diverse range of wisdom and benevolence. Visiting the ashrams and temples of saints and mystics also deepened my understanding of universality and energy, and the many things I read also supported me along my journey.

From these encounters and experiences, I learned that enlightenment is natural, and something that can be achieved by anyone, as long as you employ the right approach and practices.

Almost every day without fail, I set aside one or two hours for meditation. And with regular guidance from a meditation teacher, I deepen my awareness of my complex inner world. In meditation, the first step is to accept yourself, and then to observe your thoughts and emotions without judgment. This, as I'm sure you all know, is what we call "awareness." Awareness is something that we all experience on a daily basis, but by gradually increasing our consciousness of this "awareness," we can come to understand how meditation and climbing can reinforce one other.

Let me give you an example of what I mean by this. The act of climbing is a continuous series of infinitely varied moments. If you can objectively observe your natural reactions – your physical, mental and emotional sensations – you will start to notice many interesting things, and will make many discoveries. You will become aware of the existence of an agent that observes these physical, mental and emotional sensations. This awareness allows you to observe yourself from an appropriate distance, and gives rise to a sense of psychological stability and space. And achieving this frame of mind is something that can help climbers optimize their performance. Raising your consciousness of your own "awareness" is something that is easy to do and very rewarding, and I hope that everyone will try it out for themselves.

The state of relaxation is also something that can be deepened by meditation, and since everyone knows what it feels like to relax, I think you can understand the basic stages of this. In my instruction to competitive climbers aged 14 to 18, I tell my climbers to focus on those times in their climbing when they are relaxed and calm. By doing so, they become consciously aware of what this feels like, and it starts to come to them naturally. This helps them focus on achieving their optimal performance without being distracted by the people around them, and also allows them to enjoy themselves.

In my own climbing experience, when I was working on the 5.15b route Stoking the Fire in 2019, I managed to enter into a meditative state, and by maintaining a sense of relaxation during the climb, I achieved a sense of harmony that grew into a feeling of something like ecstasy when I clipped the chains at the end. This photo shows me when I was lowered to the ground after successfully completing the climb. I was full of joy, as you can see from the euphoric expression on my face. If you are interested, you can watch the video of this climb at the link I have provided here.

The tranquil mind that you can cultivate through meditation is an important element for achieving enlightenment. Anyone can practice being quiet, and this is something that promotes awareness and relaxation.

The wide range of senses we cultivate through meditation can help us understand and free ourselves from the traumas we endured as a result of the way we were raised or the things we experienced. I have climbed since I was 12 years old, and my climbing experience is filled with memories, both negative and positive, that I remember vividly. By being able to acknowledge both the negative and positive without judgment, I have been able to free myself from my warped sense of self-consciousness and my pride. This process is one that allows us to transcend the value elements that we tend to associate with climbing – such as style, difficulty, and comparison with others – and always focus with fresh eyes on the climbing objective in front of us. Here, the mutually reinforcing relationship between meditation and climbing can help us gain a new understanding of our past sufferings and traumas, and can even help turn this into food for the soul.

My experiences have shown me that when meditation and climbing reinforce each other, this is something that is mutually beneficial. The reinforcement received from climbing can help prevent meditation from becoming an escape from real life, instead allowing the wisdom gained from meditation to actually manifest itself in real life.

Now, I want to make sure that everyone understands that when I speak of taking meditation to a higher level, I am not talking about achieving some kind of cold objectivity, or trying to become a saint. I am talking about allowing the divisions in my heart to fuse together into a state that is more natural, warm, and innocent. About acknowledging my simple desire to do what I want to do, and the courage needed to achieve this. About freeing myself from my own narrow viewpoints and feeling the joy of developing a route that is inspired by a rock face, or a unique route that only I could create. And when I climb a route developed by someone else, I seek to wholeheartedly embrace the richness of the experience that naturally unfolds in front of me.

It is said that enlightenment is something natural that anyone can achieve as long as they employ the right approach and practices, and if my daily practice of climbing and meditation brings these two elements closer to each other to the point that they eventually completely overlap, I believe that climbing enlightenment is something I can achieve. I have been taught that letting go of my expectations and putting my faith in the great power of nature is the final step, so I will keep up my efforts as I wait for this time to come. I also hope to fill myself with an awareness of all things, not just those related to climbing, and if this imbues me with an appreciation for the richness of the present moment, my life will be a happy one.

When I encountered the enlightened people I met and felt the diversity of their wisdom and benevolence, and when I experienced their universality and energy, something resonated within me. The qualities that defined their existence were like tiny vibrations, invisible to the eye, which rippled out into the world beyond them. Anyone can feel these vibrations, and all of us give out our own vibrations too.

When I was at the climbing gym the other day, there was a young boy who was climbing. The boy was with his father, who was being very hard on him, and I could feel the boy's emotional pain as vibrations that rippled out around him. I myself was working on a difficult route at the time, and I remember how this affected me. I felt my mood and energy go down, and my body suddenly felt very heavy. However, when I got to the crux of the route, I felt a powerful burst of energy from inside me, and I let out a huge shout and lunged toward the next hold with all of my might. I completely missed it – but I was filled with an intense joy, and I was laughing as I fell. For me, falling is also something that is an important and enjoyable part of the climbing experience. After that, the serious mood of the gym vanished, and the father stopped being hard on his son. This experience showed me how we all give off vibrations, and how they can affect the people around us in positive and negative ways.

Depending on my approach, these past six years of practicing meditation and climbing could have ended up being a purely selfish endeavor. However, my climbing and meditation have reinforced each other, and have helped me to cultivate the qualities of awareness, relaxation, and serenity – as well as a sense of enjoyment that has set my climbing free – and I believe that this is communicated not only through the vibrations felt by those around me, but also through my writings and videos, social media, and many other outlets. Even though vibrations are invisible to the eye, they have the potential to change the consciousness of other people in positive ways. By continuing my study of meditation and climbing, and by finding the greatest possible enjoyment in what I do, I will seek to send positive vibrations to the climbing community. And when I finally achieve climbing enlightenment one day, this will be something I dedicate to the world around me.

I am very grateful for having been given the opportunity to speak in front of you today, and thank you for listening to my ideas on enlightenment and the reciprocal relationship between meditation and climbing. If they have given you anything to think about, I hope you will keep hold of this "awareness," and see where it takes you. It may lead to a clear question or doubt, or you may just notice a slight difference in your physical or emotional state. If you can objectively observe your physical, mental and emotional sensations without judgment, a transformation will begin. It is through such small steps that we can raise our consciousness of our own "awareness," and over time, this brings about positive changes in behavior. And this in turn can lead to a state where we are continually achieving a clearer awareness and continually making positive changes. As we move forward through these stages, this is where the process of enlightenment begins.

Thank you.

DAY 3 (13TH NOVEMBER)

Plenary lecture 3

Practical applications of climbing research -- Evidence-informed approaches to training by Taylor Reed (The Beta Angel Project, Secretary of the IRCRA)

The practical application of science is arguably one of the most important and challenging topics in research. Indeed, bridging science and practice is one of the key values of the IRCRA. The science built around climbing has seen steady growth but the practical potential of research -- from the viewpoints of trainers, athletes, and recreational climbers -- can sometimes be challenging to understand and identify. The presenter will discuss the practical potential of research, heuristics used by practitioners, the relationship of a training plan with climbing-related research, how evaluation and measurement inform training, and end with recommendations for the academic community from a practitioner's perspective.

Special Report from Japan 3.1

The Potential benefits of Climbing in Outdoor Education

– In Terms of Self-Expansion and Nature Experience – by Masako Harigaya (Meiji University)

"Outdoor education" is a general term for education that makes the most of the natural environment, and is a similar field to adventure education or environmental education. It aims at the development of the participants and their learning about the natural environment through outdoor activities such as camping, mountain climbing, and waterside activities, and includes school camp in school education. Varied terrain and courses of climbing or stream climbing in nature are very fascinating, and these could have a variety of positive effects on education.

In this discussion, I will first introduce some practical examples of climbing in outdoor education, and focus on the following two aspects of these activities: effects on self-expansion and usefulness as nature experience activities.

Main Discussion

1.Practical examples of climbing in outdoor education

Here are four examples of climbing in camps and programs organized for outdoor education.

Photo 1: rappelling at a waterfall

1) Walking in a stream during a children's camp (Tochigi Prefecture):

It was held as the main program on the third day of a five-day camp. From the campsite, we walked for about two hours along a mountain path, reached the river, walked through the stream, and came back along the mountain path. Children experienced rappelling at a small waterfall that appeared in the middle of the course (Photo1). Actually, they are deaf and hearing impaired children, so it is very difficult to give them instructions. Before we started, we carefully explained the method (in sign language) and had multiple staff members in place. The scenery of the stream was very beautiful, and the children who finished enjoyed the time and the atmosphere while waiting for their friends.

2) Climbing in a stream during a children's camp (Shizuoka Prefecture):

It was conducted as a group activity on the third day of a relatively long camp of nine days and eight nights. It's a course through a stream in the mountains at the foot of Mt. Fuji (photo 2). We went to the trailhead by mountain bike for about 40 minutes, then walked for about 30 minutes to get to the stream. There was a waterfall at the beginning of the climbing, and children climbed it one by one using a simple belay. It is not a difficult course, but it is very dynamic as children climb through waterfalls and get splashed on a lot. There is a trail on the side (escape route), so if they really don't want to do it, they can avoid it. The children's faces smiled after they climbed up.

3) Climbing during a student's camp (Yamanashi Prefecture):

Five to eight students who chose to participate in rock climbing from among the courses offered as the main program on the third day of a four-day camp. This is a mountain area around Fuji Five Lakes, and we need to walk up a steep mountain path for about an hour to the rock. Depending on the number of participants, two to four routes are set up, ranging from easy to difficult, and the staff belays the climbers at first. Once they get used to the process, students now took turns belaying each other and challenge each other at their own pace. Only about one or two students were able to complete the most challenging routes.

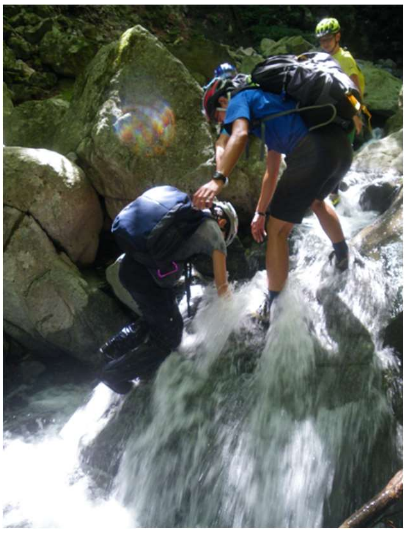


Photo 2: walking in a stream

4) Rock climbing for adults (Australia) :

This was not an activity during a camp, but was a pre-program for a conference on outdoor education (photo 3). There were only two participants including myself, but the two instructors prepared several courses for us. The approach was flat and easy, but the location of rocks were amazing, and it was exhilarating just to be there.

2. Effect on self-expansion

At camps, where people live outdoors away from their daily lives for a certain period of time, they feel differently than usual because they live a simple life of "eating, playing, and resting" in nature. There are also many situations that require active communication and ingenuity with peers and leaders. Climbing that prepared in the flow of such a life outdoors, is not just an activity to challenge and overcome, but may provide a more complex stimulus. This stimulation may help children to increase their capacity and to achieve self-acceptance, which is to know who they really are and to allow themselves to be whole. In addition, it could be an opportunity to discover a different side of their friends, to share their fun, to support and celebrate each other's challenges, and to reevaluate their own ideas and roles among others.


Photo 3: on a beautiful rock in Australia

3. Usefulness as a nature experience activity

Climbing and stream climbing in the natural environment involves grasping the rock surface or trees directly, exploring the varied rocks at the bottom of the river, getting bathed in the river water, and we rely only on our own strength, sharpening our physical senses as we go. The condition of the rock varies depending on the surrounding environment and the age of the rock: white, black, hard, brittle, rough, beautiful crystals, etc. The difficulty of the climb depends on the weather and other factors, and the altitude can easily be felt. The approach may be steep, or there may be a river or ocean beside the rocks. So, it is an activity that allows us to confront nature and feel a sense of oneness with nature. It is also said that activities in nature stimulate all five senses, resulting in a lively mind and nurturing sensitivity. Sensitivity is not the ability to just feel, but is defined as "the active ability to notice things of value," and is essential for human growth. In addition, in these days when there are concerns about the deterioration of the natural environment due to climate change, nature experience activities are very important, and their quality is required in order to foster a spirit of knowing and caring for nature. Climbing in nature could plays a big part in this sense, too.

Summary and Outlook

Rock climbing and stream climbing, using the natural environment, are activities that can bring a variety of benefits and enjoyment. In particular, they have the potential to positively influence the growth and form good sense of values in children and youth. It is also beneficial as a nature experience activity.

While there is a great deal of research on the positive changes in participants through camps as a whole. However, most of the research on the effects of climbing has focused on activities in indoor climbing facilities, and there are few examples of studies that specifically focus on climbing in natural environments. It will be necessary to obtain more specific data, such as by conducting a questionnaire survey.

Special Report from Japan 3.2

Importance of National Sports Festival for Sport Climbing development in JAPAN by Shinji MIZUMURA (Board member of JMSCA, Japan)

I'm a board member of Japan Mountaineering and Sport Climbing Association who is in charge of the sport climbing competitions of National Sports Festival. The Festival was founded in 1946 as an annual multi-sports event in Japan. In 2002, lead climbing discipline was included with trail running into Mountaineering sport competition. It was team competition. In 2008 Bouldering was adopted together with Lead climbing, and Bouldering and Lead have become a team combined disciplines. These disciplines are team competitions of two athlete competing in a total of four categories, two genders of men and women, and two age groups of boys (Youth A and B) and adults (older than Youth A) in 47 Prefectures. I will talk about how the National Sports Festival has important role for developing Sport Climbing competitions in Japan.

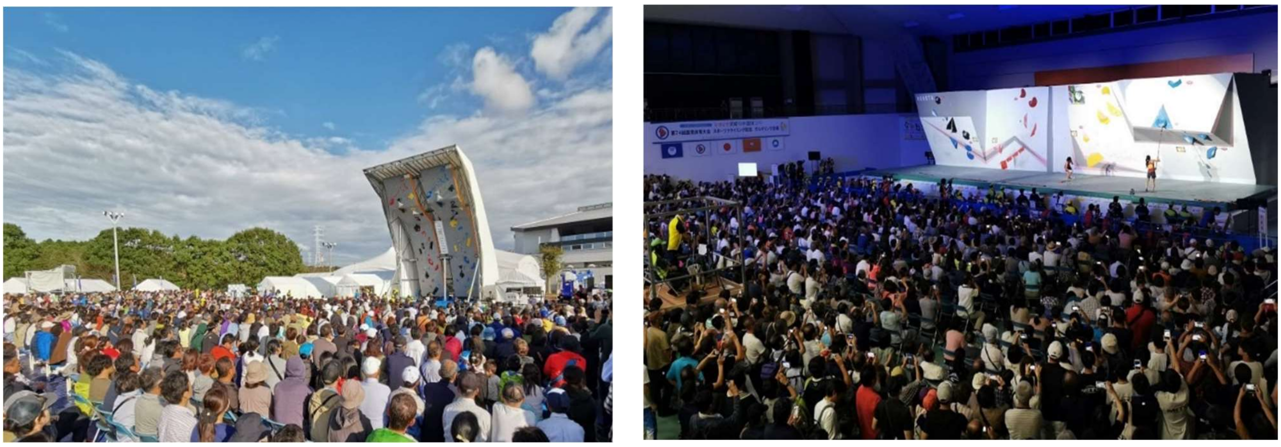
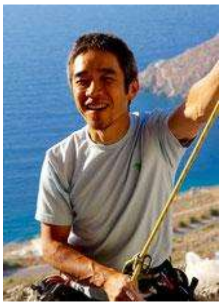


Photo 1. Lead (Left) and Bouldering (Right) disciplines in Ibaraki Competitions held in 2019

Keywords: Team competition, Combined, Bouldering & Lead, National sports, multi-sport festival

Special Report from Japan 3.3

Why I want to create an environment where people with disabilities can start climbing anywhere in Japan by KOBAYASHI Koichiro



Paraclimbing in Japan has been in process of progress from two perspectives, one is progress of Paraclimbing athletes' strength, and another is inclusion of society through climbing activities. I am a blind climber who established a non-profit organization which promote Paraclimbing in 2005. When I established it, Paraclimbing was too minor to be recognized, so I was refused not to get involved especially by the specialists who supported people with disabilities. We started the climbing school for blinds and many blinds people have got involved into climbing because they knew climbing was fun and safe for them. In 2007, the first Paraclimbing competition in Japan was held. The competition is a passion for climbing and is the goal of people with disabilities to reach the top since held first competition. As an inclusive perspective, not only blind people but also other people of disabilities have come to join climbing communities, such as def. people, people with amputated leg or arm, and people who use a wheelchair. In 2012, we started inclusive climbing events. We were not certain that if people who have no disabilities enjoyed themselves, but they liked it a lot. They say there is no other place to meet people with disabilities as friends. Climbing is a great activity that whether you are a parson with disability or non-disability or not, people can climb at the same place and possibility to share joyful time. We found climbing has the potential and value to create a more mature and prosperous society, such as promoting understanding of diversity and inclusion. In Japan, we have been expanding nationwide inclusive climbing events which both people with disabilities and without disabilities can enjoy together. Japanese Paraclimbing as athlete sports was once a part of Japan Mountaineering and Sport Climbing Association (JMSCA). However, it was separated from the JMSCA with intention of them in January 2018, which I felt so sad. We believe that we immediately established Japan Paraclimbing Association to further support people with disabilities climbers who are aiming for competition. Inclusion is one of the keys to promote better future society, so we hope that climbing society can show we can make inclusive and diversity for the society. This can be one of role climbing can do because of climbing. One of the goals is that creating an environment where people with disabilities can participate in climbing in all regions of Japan, and beyond that, we will try to spread climbing for people with disabilities to Asian countries. To that end, I would like to do my best as a climber and an athlete for the development of climbing for people for disabilities.

DAY 4 (14TH NOVEMBER)

Plenary lecture 4

Sport climbing debut at Tokyo 2020

from the personal point of view who was in the middle of the storm

by KOBINATA Toru (IFSC VP Sport Manager of TOCOG)

One of the biggest topics in the climbing community of this year 2021 is, definitely, the debut of Sport Climbing at the Tokyo2020 Olympic Games. KOBINATA, IFSC VP who also was Sport manager of TOCOG will tell you the r story of the preparation as well as Olympic structure. You will get to know more details of the Olympics and the Sport Climbing debut and how that significant climbing walls were prepared to welcome our first Olympian. The story until you watched sport climbing on TV.

Keywords: Tokyo: 2020 CLB, Olympic org, Structure, Huge complex, Tokyo BID committee, TOCOG Tokyo Organizing Committee of Olympic Games, IFSC 2020 bid team, Sport manager, CLB team, The venue, CLB team structure, OSE Official Sports Equipment, Sole supplier, the Wall, Clean venue, Rule 50, IF visits, Test event, Postponement, Removal of the panels, Countermeasures, Tokyo2020 OPEN, AUP 3x3 to CLB the Biggest Challenge, CLB debut

Looking back to Tokyo2020

Germany climbs to Tokyo 2021 by Stoecker Urs (Swiss Alpine-Club, Switzerland)

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The preparation of the German climbing team started in spring 2017 in line with the governmental support of the national Olympic committee. In this presentation, the strategic outline, measures and selection of athletes and general planning of the activities 2017-2020 are shown. The preparation in the year 2021 is explained in more details with focus on the months before the Olympic Games. In addition, the results of the German athletes in Tokyo are analysed and discussed in detail and personal conclusions are drawn.

Keywords: Olympic preparation; Tokyo 2020; German climbing team; sport climbing; bouldering; Olympic combined.

Acknowledgements: we thank the board of IRCRA for organizing this congress. We also thank our sponsors for their help.

Development of Japan National Team for the Tokyo 2020 Olympic Games by YASUI Hiroshi (Head coach of Japan National Team)

Since 2016, I have led the development of athletes for the Tokyo 2020 Olympics as the head coach of Japan National sports climbing team. I would like to briefly introduce the efforts to development the new events of lead, boulder, and speed combined events and the development of the athletes of the Japanese national team.

Road to World Record by MIROSLAW Mateusz (Head coach of Polish National Speed Team)

I've started training Ola almost 7 years ago and end up being head coach for Poland National Climbing Team in speed climbing. I would like to show you our journey, training philosophy and what it took to break a world record at the Olympics. Will give you a sneap peak of our training log to demonstrate the correlation between athletes strength in specific movement, how it changes during course of years and the athlete ability to run faster. And Ola will talk about her impression about her first Olympic Games.

One Goal - Gold Medal by KRAJNIK Roman (Personal Coach of Janja Garnbret)

KRAJNIK Roman is a personal coach of Janja Garmbret who won the Gold medal of Women's Combined Discipline in the Tokyo 2020 Olympic Games. He will talk about his effort he did for her. His talk will deserve the final lecture of this Congress.

LIVE PRESENTATIONS

Day 1 - Session 1

OVERUSE ELBOW INJURIES IN ROCK CLIMBING WITH A FOCUS ON EPICONDYLITIS

Neumaier M[(1)], Lutter C [(2)], Schöffl V[(3)]

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Abstract

Background: Epicondylitis is the most common elbow overuse injury in sports climbing. Even though this has been shown years ago, literature on etiology and risk groups is pending, but indispensable regarding the target to establish preventive care.

Purpose: The target of this study is to evaluate risk factors for epicondylitis in sports climbing.
Study design: Case series, level of evidence 3
Methods: Based on prior work we established a database of our injured climbing patients, including a questionnaire on demographic data, training routines and climbing level. Of those 770 patients recorded we extracted a group of 41 with epicondylitis cases to examine their relevant data to the remaining collective. Results have been tested on significance with a standard level of significance =5%. Furthermore, we evaluated risk groups and training as well as climbing habits which led to a significantly higher incidence of epicondylitis.
Results: During a three-year period a total number of 41 patients (age: 36,8±8,6(19-51), 28 males, 13 female) with epicondylitis have been seen for clinical examination and were included in the study. The patients were climbing an average of 14,8±10,8 years and bouldering for 6,9±5,5 years. The level of climbing was specified in the V-Scale and was 8,7±1,2. Furthermore, they mentioned to spend their training time 49,6±30,9 % with sports climbing and 47,2±31,3 % with bouldering. Compared to the 770 patients recorded over those 3 years, the patients who presented with an epicondylitis climbed significantly stronger and longer. These increased incidences were only present in correlation with sports climbing level and years climbing. It did not correlate with level of bouldering or years bouldering.
Conclusion: In conclusion long year stronger climbers showed a higher incidence of epicondylitis. Further awareness of those specific risk factors is important to develop prophylactic and preventive measures.

Keywords: overuse injuries, elbow, epicondylitis

Acknowledgments: We thank the board of IRCRA for organizing this congress.

FINGER FLEXOR PULLEY INJURIES: A REVIEW

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ABSTRACT:
Background: Injuries of the Finger Flexor Pulley System (FFPS) are the most common overuse injuries in the rock climbing population. Given the sport's continued rise in popularity, these injuries will increase in prevalence and the diagnosis and treatment of these injuries will also grow.
Purpose: The objective of this study is to comprehensively review FFPS injuries, including the most recently developed new diagnostic and therapeutic algorithm.
Study Design: General Narrative Review
Methods: Literature search performed with MeSH terms as headings to meet the requirements of this review.
Results/Conclusion: Use of the "crimp grip" is the major culprit in rock climbing for injuries of the FFPS. The A2, A3, and A4 pulleys are most commonly injured, and are at increased risk when eccentrically loaded. Clinical bowstringing does not suffice for diagnosis, and imaging with ultrasound (US) is the gold standard of evaluation. Magnetic Resonance Imaging (MRI) can be used as a further investigative study if US evaluation does not reveal the diagnosis. Imaging diagnostic thresholds are discussed. The table below representing the newest diagnostic and therapeutic classification system will be reviewed and discussed.

KEYWORDS: pulley injury, ultrasound, pulley algorithm

	Grade I	**Grade II**	**Grade III**	**Grade IV a**	**Grad IV b**
	Pulley strain	Complete tear of A3 or A4, partial tear of A2	Complete tear of A2	Multiple ruptures: - A2/A3 or A3/A4 Rupture if: - No major clinical bowstringing - Ultrasound proven possibility of reposition of the flexor tendon to the bone - Therapy starting < 10 d after injury - No contracture	Multiple Ruptures: - A2/A3 or A3/4 with obvious clinical bowsrting - A2/A3/A4 Rupture - Singular pulley rupture with FLIP phenomen - Singular rupture with increasing contracture - Singular rupture with secondary, therapy resistant, tenosynovitis
Therapy	Conservative	Conservative	Conservative	Conservative, if secondary onset of PIP contracture >20° secondary surgical	Surgical
Immobilization	None	Optional, < 5 days	Optional, < 5 days	Optional, < 5 days	Post-surgical 14 days
Functional therapy with pulley protection (defined)	2-4 weeks H-tape (during day time) or thermoplastic ring (pulley protection splint)	6 weeks thermoplastic pulley ring (pulley protection splint)	6-8 weeks thermoplastic pulley ring (pulley protection splint)	8 weeks thermoplastic pulley ring (pulley protection splint)	4 weeks thermoplastic ring (after 2 weeks of immobilization)
Easy sport specific activities	After 4 weeks	After 6 weeks	After 8 weeks	After 10 weeks	After 4 months
Full sport specific activities	After 6 weeks	After 8-10 weeks	After 3 months	After 4 months	After 6 months
H-taping during climbing	3 months	3 months	3 months	>12 months	>12 months

FINGER FLEXOR TENOSYNOVITIS – THE ROCK CLMIBER`S MOST FREQUENT CHRONIC BURDEN

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Keywords: sport climbing, tendonitis, flexor tendon, tendon sheath

ABSTRACT

Purpose

The most frequent climbing-specific injuries are found in the hand and fingers, with the most acute overstrain injury identified as finger flexor tenosynovitis. While many finger conditions in climbers have been extensively studied, no data exist on the therapy of flexor tendon tenosynovitis. The purpose of the study is to evaluate the patient outcome after treatment in accordance with our regimen.

Methods

The study included rock climbing athletes suffering from tenosynovitis of the finger flexor tendons in 2017. All patients were treated following our stage-related treatment regimen, according to the severity and time-frame of clinical and imaging findings. Early stage cases (Stage 1: symptoms less than 6 weeks) received conservative therapy, while Stage 2 cases received a steroid injection twice within seven to ten days. Patients who were not healed by these injections then underwent medicinal leech therapy (Stage 3). Six months after the completion of treatment, a reevaluation was performed with a questionnaire and Buck-Gramcko, functional and sport specific scores.

Results

50 patients with tenosynovitis of the finger flexor tendons were extracted from our climbing patient database from 2017. Seven patients received primary conservative therapy and 42 received local steroid injections. Four out of the seven conservative patients healed within eight weeks and regained their initial climbing level. The remaining three did not, and subsequently underwent steroid injections. Forty-two patients received steroid injection therapy with two injections. Thirty-one of the climbers (73.8%) were pain free after the second injection and a mean time frame of 20.9 ± 23.1 days. The remaining eleven did not become completely pain free. Within the injection group, we found a decrease of symptoms of 84.2%

after the second injection. In eight patients, a secondary medicinal leech therapy was performed. The sport-specific outcome score of all 42 injection patients was excellent in 26 (62%), good in nine (21%) and satisfactory in seven (17%) patients. After leech therapy, the sport-specific score was excellent in two and good in six patients. No complications occurred.

Conclusion

While the initial conservative management in tenosynovitis is in accordance with literature, the positive outcome after steroid injection therapy and the absence of complications justifies this as a second-stage approach. The medicinal leech therapy proved to be a good alternative.

Day 1 - Session 2

10-YEAR FOLLOW-UP STUDY OF CARTILAGE ABNORMALITIES AND OSTEOPHYTES IN THE FINGERS OF ELITE SPORT CLIMBERS: A CROSS-SECTIONAL

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Abstract:

The sequelae of high mechanical stress to the proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints of the fingers in elite sport climbers and its contribution to the development of osteoarthritis are still relatively unknown. The purpose of this study was to investigate the evolution of cartilage abnormalities of the PIP and DIP joints, as well as the progress of osteophytes, in the fingers of elite sport climbers with a minimum of 25 years of climbing history over the time period of the last 10 years. Moreover, their actual cartilage abnormalities and osteophyte occurrence were compared to non-climbing age-matched controls. 31 elite male sport climbers and 15 male non-climbers underwent a sonographic examination of the PIP and DIP joint cartilage and osteophyte thickness in the frontal and sagittal plane as well as and conventional radiographic investigation of digits II to V of both hands. The same cohort had already been measured with an identical protocol ten years earlier (follow-up-rate of 100%). Compared to the baseline assessment 10 years earlier, the cartilage thickness of sport climbers has significantly decreased; however, it was still greater than in age-matched controls. Moreover, sport climbers showed significantly higher relative frequencies of osteophyte occurrence than non-climbers (all fingers and joints). Nevertheless, despite a substantial (and compared to baseline a further increased) occurrence of osteophytes in elite sport climbers, there was no association between the radiological signs of osteoarthritis and pain within the last 6 months prior the follow-up investigation.

Keywords: athletes; climbing; finger joint; hand; injury; osteoarthritis; overuse.

YOUTH CLIMBER EPIPHYSEAL PLATE FRACTURES FROM A PHYSIOTHERAPY PERSPECTIVE

DeStefano M.

Onsight Sports Medicine; Mesa Rim Youth Climbing Team, California, USA. matt@onsightsportsmed.com

Abstract

Epiphyseal plate fractures in youth climbers were first reported in 1997. Since this date, little if any information regarding these injuries has been published from the perspective of physiotherapy and rehabilitation to match the excellent resources collected from the medical perspective. Through collaboration with other doctors and surgeons to develop an efficient rehab plan to follow, a physiotherapy protocol is proposed for those returning to climbing after sustaining an epiphyseal plate fracture. Following complete bone healing, rehab methods include gradual reloading of the finger utilizing slings and dumbbells or portable crimp blocks and dumbbells to target affected tissues. Half crimp grip will be administered initially for approximately 2-4 weeks before reintroducing the full crimp. After 2-4 weeks of gradually increasing loads with weights, athletes will begin a hangboard protocol utilizing a pulley system to offload bodyweight. Bodyweight percentages will be calculated and administered on a 25%, 50%, 75% and 100% interval. Over the course of 6-8 weeks, the athlete will have gradually reintroduced the affected finger to the specific loads of climbing, adhering to Wolff's and Davis's Laws for bone and tissue remodeling.

Keywords: IRCRA2020; Rock climbing; Growth plate fracture; Rehab protocol

Acknowledgements: Thank you to Dr. Yasser El-Sheikh, Dr. Isabella Shöffl, Dr. Volker Schöffl, Dr. Andreas Schweizer and any others who have contributed to this growing body of research.

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EVALUATION OF A DIAGNOSTIC-THERAPEUTIC ALGORITHM FOR EPIPHYSEAL GROWTH PLATE STRESS INJUREIS IN ADOLESCENT CLIMBERS

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Abstract

Background: Epiphyseal growth plate stress injuries are the most frequent specific injuries in adolescent climbers. Definitive diagnostic and therapeutic guidelines are still pending.

Purpose: The objective of this study was to evaluate a diagnostic–therapeutic algorithm for epiphyseal growth plate stress injuries in adolescent climbers.

Study design: Case series; Level of evidence, 4.

Methods: Based on prior work on diagnostics as well as conservative and surgical therapy of epiphyseal growth plate stress injuries (EGPI) in adolescent climbers, we developed a new algorithm for both, diagnostics and therapy, which was implemented into our clinical work. During a four-year period, we prospectively performed a multi-center analysis of our patients treated according to the clinical part of the algorithm. Climbing specific background (training years, climbing level, training methods etc.) was evaluated, injuries analyzed (Salter-Harris classification and UIAA MedCom score) and therapies and outcomes recorded (osseous healing, time to return to climb, Visual Analog Scale (VAS), Quick-DASH and a climbing-specific outcome score).

Results: Within the observation period, a total number of 27 patients (age: 14.7 ± 1.5, 19 male, 8 female; 66.7% competitive athletes) with 37 independent EGPI were recorded. Average UIAA climbing level was 9.5 ± 0.8 with an average of 6 ± 4.6 years of climbing or bouldering and a mean weekly climbing-specific training volume of 14 ± 9.1 hours. Among the 37 injuries there were: 7 epiphyseal strains, 2 Salter-Harris 1 fractures and 28 Salter-Harris 3 fractures (UIAA 1: 7, UIAA 2: 30). Thirty-six injuries developed over a longer time-period while only one had an acute onset. 28 injuries were treated conservatively, 9 surgically. Osseous healing was achieved in all cases and there were no reoccurrences. The climbing break after therapy start was 40.1 ± 65.2 days. The climbing specific outcome score was excellent in 34 and good in 3 cases. VAS decreased from 2.3 ± 0.6 to 0.1 ± 0.4 points after therapy and Quick-DASH from 48.1 ± 7.9 to 28.5 ± 3.3.

Conclusion: The proposed algorithm led to an osseous healing in all cases. Early CT scan helps to detect cases with suspected non-healing and triggers a surgical intervention. Further awareness of EGPI is important to develop prophylactic and preventive measures.

USING TELEHEALTH TO TREAT TRICEPS TENDINOPATHY IN A ROCK CLIMBER

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Abstract

This case study presents a 38-year-old, female rock climber with posterior elbow pain who was evaluated and treated using Telehealth. The use of telehealth for a clinical exam requires a larger emphasis be placed on posture observation and movement analysis since hands on assessment techniques cannot be used. During the patient exam, movement analyses identified scapulohumeral positional faults and dyskinesis, while self-palpation and self-midline resistance testing helped identify that the triceps tendon was the pathological tissue. A comprehensive rehabilitation program was developed based on concepts of regional interdependence to treat contributing factors in the scapular region and source tissues in the brachial region. After 10 weeks, the climber's pain decreased from 4/10 to 0/10 and she made a full recovery back to her previous grade of V8 bouldering.

Keywords: Physical Therapy; Elbow Pain; Regional Interdependence

Introduction

Since COVID-19 emerged in the first months of 2020, social distancing and stay-at-home orders moved telehealth from a convenient option to an essential tool (Lee, 2021). As a result of nation and local mandates, many medical providers who treated climbers had to adjust their practice models to include remote care. In the field of physical therapy, Telehealth has several strengths and several drawbacks when compared to the in-person setting. Most notably, since manual assessments cannot be performed by the clinician, the objective exam has a greater emphasis on movement analysis (Malliaras et al., 2021). This reliance on analyzing a climber's movement allows the clinician to look past the affected pain region and integrate concepts on regional interdependence (Wainner, Whitman, Cleland, & Flynn, 2007) into their diagnostic procedures. Regional interdependence is a concept that unrelated impairments in a remote anatomical region may contribute to or be associated with the patient's primary complaint. By using this concept remotely, clinicians may be able to uncover impairments that may have been missed in an in-person clinical exam that was solely focused on the painful region. This paper is a case study that demonstrates how Telehealth can be used successfully to evaluative and treat a rock climber with posterior elbow pain.

Methods

A 38-year-old, female rock climber was evaluated for elbow pain. She had 20 years of bouldering experience with a maximum grade of V12 and a pre-injury grade of V8. She reported a minor right ring finger injury 6 weeks prior to the evaluation and an acute left ankle sprain 4 weeks prior to the evaluation. The evaluation was performed remotely utilizing Telehealth. She presented with 4-months post-partum with right sided posterior elbow pain superior to the olecranon. She reported push-ups, bench-press, and wiping counters increased her elbow pain from a 0/10 to a 4/10. She also reported hard bouldering moves such as lock-offs and gastons increased her symptoms. She denied any numbness or tingling. The remote clinical examination included a posture analysis (Fig. 1) and a movement analysis of shoulder abduction (Fig 2.), shoulder flexion with elbow flexion (Fig 3.), offset pushups (Fig. 4), climbing movement (Fig. 5), and self-assessment of palpation and midline resistance testing. Posture and movement analysis demonstrated asymmetric scapulohumeral positional faults and dyskinesis including excessive scapular winging, inadequate scapular elevation/upward rotation, and excessive humeral internal rotation with shoulder flexion. Self-palpation reproduced symptoms with moderate pressure and midline resistance testing of elbow extension was provocative for symptoms at 90 degrees of shoulder flexion (4/10) and 0 degrees of shoulder flexion (2/10).

Figure 1: Winging of the inferior angle of the scapula right greater than left indicating serratus anterior weakness

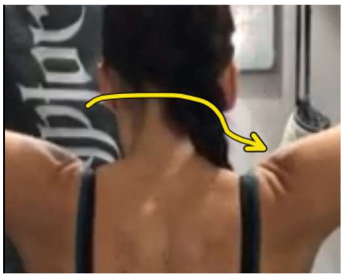

Figure 2: Increased right sided humeral creasing with shoulder abduction indicating possible humeral hypermobility and inadequate scapular upward rotation and elevation

Figure 3: Right humeral internal rotation with shoulder/elbow flexion indicating a latissimus dorsi mobility deficit

Figure 4: Right sided scapular winging with offset pushup indicating serratus anterior muscle weakness

Figure 5: Scapular winging with climbing movement on overhung wall indicating serratus anterior muscle weakness

Based on the subjective reports and objective data gathered remotely, the patient was given a home exercise program based on a rehabilitation framework to unload the affected tissues, improve mobility, increase muscle performance, and retrain climbing movement (Vagy, 2016). Each intervention was specially linked to a hypothesis driven impairment remotely tested during the session. Interventions consisted of patient education to carry her baby with her left arm and avoid leaning on the elbow. Her mobility exercises consisted of posterior rotator cuff and latissimus dorsi soft tissue mobilization followed by latissimus dorsi stretching. Each exercise was prescribed for 3 sets of 30 seconds daily. Her muscle performance exercises consisted of push-up plus airplane, wall taps, and triceps eccentrics performed at 0, 90 and 180 degrees of humeral flexion. Each exercise was prescribed for 3 sets of 8 repetitions and performed 3 times per week. The patient was encouraged to return to her regular climbing schedule of 4 session per week and to avoid routes with the excessive use of slopers, gastons, and mantles.

Figure 6: (From top left to bottom right) Tennis ball on posterior rotator cuff, latissimus dorsi soft tissue with foam roll, latissimus dorsi / triceps stretch with dowel, pushup-up plus airplane, wall taps, triceps

eccentrics 0 degrees humeral flexion, triceps eccentrics 90 degrees humeral flexion, triceps eccentrics 180 degrees humeral flexion.

Figure 7: Organization of rehabilitation into a framework

At 10-week follow-up the patient reported that her triceps pain was 0-10 and she had returned to training and climbing pain-free at her previous grade of V8 without restriction.

Results and Discussion

As a result of the remote environment, a large emphasis in the evaluation of the patient relied on subjective information and movement analysis. During movement analysis, it was discovered that the patient demonstrated scapulohumeral positional faults and dyskinesis including excessive scapular winging, inadequate scapular elevation/upward rotation, and excessive humeral internal rotation with shoulder flexion. It has been shown in research that scapular positioning and dyskinesis affect the elbow and when addressed can resolve elbow pain (Bhatt, Glaser, Chavez, & Yung, 2013). It has also been shown that eccentric exercises can have positive effects on pain and function in patients with lateral elbow tendinopathy (Page, 2010), and even more recently it has been shown that eccentric-concentric training combined with isometric contractions is an effective treatment for lateral elbow tendinopathy (Stasinopoulos & Stasinopoulos, 2017). However, most studies have focused on lateral elbow pain and not posterior elbow pain. This is the first case study of its kind to identify unilateral scapular dyskinesia in a patient with suspected triceps tendinopathy and to demonstrate a positive treatment effect by combining scapular strength exercises with eccentric exercises addressing the affected tissue.

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Day 2 - Session 1

EFFECT OF HIGH-INTENSITY CLIMBING ON PERFORMANCE AND CORRESPOINIDNG MUSCLE OXYGENATON RESPONSE

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Abstract

High-intensity training (HIT) is known to have deteriorating effects on performance which manifest in various physiological changes such as lowered force production and oxidative capacity. However, the effect of HIT in climbing on finger flexor performance has not been directly investigated. Twenty-one climbers partook in an intervention study with three assessment time points: pre-HIT, post-HIT, and 24-hour post-HIT. Assessments consisted of three finger flexor tests: maximum voluntary contraction (MVC), sustained contraction (SCT), and intermittent contraction tests (ICT). During the SCT muscle oxygenation (SmO2) metrics were collected on the forearm. The HIT had significant deteriorating effects on all force production metrics (MVC -18%, SCT -55%, ICT -59%). Post-24h showed significant recovery, which was less pronounced for the endurance tests (MVC -3%, SCT -16%, ICT -22%). SmO_2 metrics provided similar results for the SCT with medium to large effect sizes. A strong association was found between a loss of force production and change in minimally attainable SmO_2 ($r = -0.734$, $p = .016$). This study presents novel findings on the deteriorating effects of HIT on finger flexor performance. Specifically, the divergent results between strength and endurance tests should be of interest to coaches and athletes when assessing athlete readiness.

Keywords: NIRS, HIIT, tissue oxygenation, MVC

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RELATIONSHIP BETWEEN FOREARM PUMP AND DECREASED FORCE IN EXPERT AND ELITE ROCK CLIMBERS

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Abstract

Force decrements because of fatigue have been found after climbing until exhaustion. One of the consequences is forearm pump, which is probably the hallmark of fatigue in this sport. This study aims to describe strength and forearm volume pre- and post- a specific climbing to exhaustion test in male and female sport climbers. Twenty-nine participants (6 female) were divided into two groups: expert (n = 23; 6 female, 16 male) and elite (n = 6). Maximal grip force of the right hand (MVC), forearm volume (FAV) of both sides were measured, before and immediately after a climbing to exhaustion test. The MVC_{post} decreased significantly 18% across all the groups compared to $MVC_{pre,}$ whereas no significant differences were found among the groups. We did not find sex differences in ΔFAV_{rignt} or ΔMVC after climbing. ΔFAV_{right} was significantly greater for male elite compared to expert climbers ($p<0.05$). $FAV_{postleft,}$ significantly correlated to climbing ability ($r = 0.48$; $p<0.05$), which may suggest the importance of a balanced finger strength and endurance training in climbing. The relationship observed between ΔMVC and ΔFAV_{right} ($r = - 0.41$; $p < 0.05$) could indicate that changes in muscle volume itself may be related to the force generating potential of muscle.

Keywords: fatigue, sport climbing, muscle swelling, finger strength.

Introduction

Force decrement because of fatigue has been found after continuous laps in a route set on a climbing treadwall (Heyman, De Geus, Mertens, & Meeusen, 2009; Valenzuela, de la Villa, & Ferragut, 2015; Watts, Newbury, & Sulentic, 1996; Watts & Drobish, 1998). Climbing fatigue seems to ensue from sustained isometric grips and intermittent repeated grips during a climbing route (Fryer et al., 2017). A pumped forearm or a swelling sensation and pain of the forearm muscles is probably the hallmark of fatigue in climbing, and popularly associated with an imminent fall among climbers.

The percentage loss of grip strength due to fatigue could be related to the initial maximal isometric strength. Indeed, the decrease in relative force after a climbing session on an indoor route was greater in male climbers, who also resulted to be stronger (Gajewski & Jarosiewicz, 2008) than female climbers. This familiar forearm pump, primarily an acute increase in size of the muscles in the forearm after climbing, may be explained by the increment of extracellular-to-intracellular water ratio associated with reactive hyperemia (Taniguchi, Yamada, & Ichishashi, 2019). A previous study reported forearm volume changes (ΔFAV) after a test of intermittent isometric contractions to failure in lead climbers and boulderers (Fryer et al., 2017). To our knowledge, both strength and FAV variables have not been reported after a climbing test to volitional fatigue. Studies analyzing the changes in strength and forearm volume after a climbing test to volitional fatigue would help understanding the underpinning of the training programs and their relation to sex and climbing ability groups.

Therefore, the purpose of this study was to describe strength and forearm volume pre- and post a specific climbing test to exhaustion in male and female elite and expert climbers.

Methods

Twenty-nine participants (6 female) with an average age of 37.49 ± 6.65 y and climbing experience of 14.04 ± 9.39 y were divided into two groups: expert (n = 23; 6 female, 16 male) and elite (n = 6), using the 75th percentile of redpoint climbing ability according to España-Romero et al. (2009). Their average redpoint climbing ability, as defined in the IRCRA reporting scale were 16.73 ± 3.47 and 24.17 ± 0.98 for expert and elite climbers, respectively. Maximal grip force of the right hand (MVC) using a half-crimp grip on a climbing handhold 15 mm deep was tested with the ISOMED system (P201600488, Cádiz, Spain). Participants were seated, with the elbow joint at 90º and fixed to a table. MVC_{pre} was considered as the highest value from 3 tries of maximal 5-second contractions separated by 1 minute, and only by 10 seconds for MVC_{post}. Forearm volume (FAV) comprised the area from the base of the carpus to the crease in the elbow joint, being measured to the nearest 0.5 mL using the water displacement method. Volume of each side and MVC were measured before ($FAV_{preleft}$, $FAV_{prerigh}$, MVC_{pre}, respectively) and immediately after an incremental climbing test ($FAV_{postleft}$, $FAV_{postright}$, MVC_{pos}, respectively). The climbing time to exhaustion test (TTE) was performed on a route on a rotating treadwall (Stonbasic Electric, Spain), where wall angle was increased progressively to ensure volitional exhaustion between 6 and 12 minutes. Intermediate and advanced climbers (≤ 13 to 18 IRCRA scale) started climbing on 90 degrees (vertical), and expert (≥ 19 IRCRA scale) at 96°. After 4 minutes, the angle further increased to 98°, and then to 102° and 106°. Irrespective of ability group, two minutes were spent at 98° and 102°, while the angle of 106° was maintained until participants failed to keep climbing despite verbal encouragement. Given that after the TTE test, MVC_{post} using the right hand was performed, the $FAV_{postright}$ was measured last. Data analysis was conducted using a one-way ANOVA, t-test, Pearson's correlation coefficient, and Effect size (ES) calculation. It was estimated using the mean difference and dividing the result by the pooled standard deviation (Cohen, 1988).

Results & Discussion

The MVC_{post} decreased significantly 18% across all groups compared to $MVC_{pre,}$ whereas no significant differences were found among groups (Table 1). In this line, Watts, Newbury, & Sulentic (1996) and Watts & Drobish (1998) also found a 22% handgrip strength loss in climbers from advanced to elite level, as well as beginners. While Valenzuela et al., (2015) and Heyman, De Geus, Mertens, & Meeusen (2009) observed a decrease of 16% and 45%, respectively, in intermediate level climbers.

Table 1. Mean ± SD values for forearm volume and maximum grip force before and after the climbing test.

Measure	**Whole group**	**Female**	**Male**	
	(n = 29)	**Expert (n = 6)**	**Expert (n = 17)**	**Elite (n = 6)**
Climbing time TTE (sec)	525.82 ± 136.81	414.00 ± 138.87	519.56 ± 108.98	654.33 ± 105.87*
Forearm Volume				
$FAV_{preright}$ (ml)	1089 ± 262	725 ± 74**	1212 ± 186	1104 ± 238
$FAV_{preleft}$ (ml)	1095 ± 264	737 ± 72**	1201 ± 170	1150 ± 311
$FAV_{postright}$ (ml)	1188 ± 288	792 ± 96**	1298 ± 208	1275 ± 281.
$FAV_{postleft}$ (ml)	1165 ± 277	767 ± 83**	1275 ± 183	1250 ± 276
ΔFAV_{right} (ml)	100 ± 79	67 ± 74	86 ± 74	171 ± 66*
ΔFAV_{left} (ml)	70 ± 67	29 ± 19	73 ± 68	100 ± 84
Finger strength				
MCV_{pre} (kg)	42.3 ± 10.1	26.6 ± 2.2**	45. ± 6.4	48.1 ± 6.1
MCV_{pre}/BW (ml • kg^{-1})	0.6 ± 0.1	0.5 ± 0.1*	0.6 ± 0.1	0.7 ± 0.1
MCV_{post} (kg)	34.7 ± 8.4 ‡	21.8 ± 2.5**, †	37.9 ± 4.8‡	39.2 ± 6.7†
ΔMCV (kg)	-7.6 ± 4.7	-4.8 ± 2.8	-8.2 ± 3.7	-8.8 ± 4.9

TTE: Climbing time to exhaustion; $FAV_{preright}$: right forearm volume before climbing; $FAV_{preleft}$: left forearm volume before climbing; $FAV_{postright}$: right forearm volume after climbing; $FAV_{postleft}$: left forearm volume after climbing; BW: body weight; MVC: maximal voluntary contraction; ΔFAV: forearm volume changes after climbing; ΔFAV: forearm volume changes after climbing; MCV_{pre}: maximal voluntary contraction before climbing; ΔMVC: changes after climbing. Climbing ability grouping (expert, elite) based on the best 3-month redpoint climbing grade; SD: standard deviation.

*Significantly different from male expert climbers; $p < 0.05$. **Significantly different from male expert climbers;$p<0.001$. † Significantly different from MVC_{pre} ; $p < 0.05$. ‡ Significantly different from MVC_{pre} ; $p < 0.001$

We did not find sex differences in ΔFAV and ΔMVC after climbing. Regarding male climbers, ΔFAV_{right} was significantly greater for elite compared to expert climbers (15% and ES= 0.66 vs. 7% and ES = 0.44). Some possible reasons behind this fact could be an enlarged functional capillary surface area (Fryer et al., 2015), as well as a higher forearm conductance during and immediately after intermittent isometric exercise, already reported in trained climbers as result of years of isometric training (Ferguson & Brown, 1997). Furthermore, MVC_{pre} showed significant correlation with ΔFAV_{right} ($r = 0.44$; $p < 0.05$), which could be in line with Hunter et al. (2006). They suggested that stronger subjects show greater hyperemia and vascular conductance. Finally, it may be hypothesized that elite climbers have more compliant muscle compartments compared to expert climbers (Jensen, Jorgensen, & Sjogaard, 1994). A more compliant tissue displays less resistance to mechanical deformation. It would allow an increase of muscle size without increasing compartment pressure, which is related to longer recovery and physical stress (Schoffl, Klee, & Strecker, 2006). Interestingly, we observed that $\Delta FAV_{left,}$ significantly correlated to climbing ability ($r = 0.48$: $p < 0.05$). Previous research determined that differences in grip strength (Assmann, Steinmetz, Schilling, & Saul, 2020) and load application time (Donath, Roesner, Schöffl, & Gabriel, 2013) between the dominant and non-dominant were most pronounced for lower level compared to higher level climbers. Therefore, it is plausible to suggest that elite climbers experiment a more even "pump" between sides due to a better-balanced work-relief ratio, and it may mean extended performance on a climbing to exhaustion test. A relationship was observed between ΔMVC and ΔFAV_{right} ($r = -0.41$; $p < 0.05$), which could indicate that changes in muscle volume itself may alter the force-generating potential of muscle due to an increase in passive muscle tension with a surge in muscle fluid volume (Sleboda & Roberts, 2017). Nonetheless, one limitation of our study is that the order in measuring left and right FAV after climbing was not randomized.

In conclusion, there was a significant force decrement after climbing to exhaustion related to volume changes in the right forearm, but not to the initial force, climbing ability or sex. Elite climbers experienced a significantly greater change in their right forearm volume compared to expert climbers. However, only the changes in the left forearm volume showed a relationship with climbing ability, which could indicate the importance of a laterally balanced finger strength and endurance training. Future research can be conducted to determine if the changes in the right forearm's volume after climbing may be a possible indicator of climbing-induced fatigue applicable to training load monitoring.

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PREFRONTAL CORTEX ACTIVATION DURING A CLIMBING-SPECIFIC TASK FOLLOWING COLD WATER IMMERSION

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Abstract

The prefrontal cortex (PFC) is thought to play a role in interpreting afferent feedback and determining when to terminate a fatiguing task. Cold water immersion (CWI) has shown beneficial results for recovery in rock climbing. Therefore, the aim of this study was to monitor the effects of CWI as a recovery intervention on PFC activation during a climbing-specific fatiguing task of the finger flexors. Fifteen intermediate climbers performed passive recovery or 15 mins of CWI of the forearm, during a 20 min recovery session between two fatiguing tasks. A climbing-specific finger flexor device equipped with a climbing hold and a load cell were used for the fatiguing task. Functional near-infrared spectroscopy was used to monitor PFC hemodynamics throughout testing. Following the recovery intervention, time to task failure was greater following CWI (243 vs. 154 sec; $P < 0.001$) compared to passive recovery. This improvement was accompanied by a slower increase in PFC activation (3.60 ± 1.64 vs. 5.38 ± 2.63 μmol/L/min; $P < 0.01$). Participants also rated their perceived task demands as lower following CWI. These results provide psychophysiological insights into how rock climbing performance is improved following CWI of the forearms.

Keywords: Rock Climbing; Fatigue; Recovery; Performance; Temperature

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DIFFERENCES IN MAXIMAL VOLUNTARY CONTRACTION, STRENGTH AND ENDURANCE, AND NEUROMUSCULAR FUNCTION DURING HALF-CRIMP AND SLOPE GRIP POSITIONS IN ELITE AND EXPERT ROCK CLIMBERS

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Abstract

Handgrip technique, as well as the maximum grip and endurance of the forearm muscles is of great importance for increasing performance in climbing, and may differentiate ability groups. To date, most research has studied the neuromuscular changes or the force development in only the half-crimp grip position, using electromyography (EMG). To our knowledge, no study has compared the forearm EMG response to half-crimp and slope grip positions. As such, we analyzed maximal voluntary contraction (MVC), EMG and strength and endurance characteristics during an intermittent test to failure in both a crimp and slope positions, in both expert and elite climbers. Twenty-one sport climbers performed the tests in both a half-crimp and a slope grip position using the ISOMED system. Flexor digitorum profundus muscle frequency by EMG activity was recorded throughout. There were no significant between ability group differences in MVC (expert vs. elite) or climbing grip positions (half-crimp vs. slope). Elite climbers recorded significantly more contractions than expert climbers (P=0.005). The EMG response was significantly greater during the crimp compared to the slope grip position.

Keywords: grip strength, maximal voluntary contraction, intermittent strength, Flexor muscle, EMG

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Day 2 - Session 2

THE NINEHEIGHT MACHINE LEARNING-BASED CLIMBING STANDARD SYSTEM

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Abstract

Identifying the variables that define the difficulty of a climbing sequence is a necessary preliminary step to designing a mathematical solution to the difficulty standardization problem through supervised Machine Learning algorithms. The NineHeight Machine Learning-Based Climbing Standard System (9H8) aims to complement Standardized Interactive Systems (SIS) to its application on any type of climbing scenario by creating objective knowledge to overlay, compare and contrast any situation on which a climbing sequence can be defined. A sample of 1167 climbing sequences from 5+ to 8a+ was used: of between 3 and 10 nodes (compossed by an overall 7798 holds, classified as 189 characteristic node identifiers), over 5 differents climbing surface configurations and confirmed by climbers worldwide in 2.092.317 climbing attempts (all data recollected and compiled trought the NineHeight data base). Two supervised machine learning algorithms were developed and tuned in their parameters to obtain the most accurate predictor of the difficulty level. The accuracy of the model was 99.99% in the whole sample. Therefore, the method proposes an objective classification of the difficulty of the sequences. In addition, it has been identified that the most important factor in determining the difficulty of a sequence is the node value.

Keywords: Machine Learning, Artificial Intelligence, Climbing Standard System, difficulty grade.

Background/Purpose: Identifying the variables that define the difficulty of a climbing sequence is a necessary preliminary step to designing a mathematical solution to the difficulty standardization problem. Such mathematical solution does not exist yet (Ondra, 2020; Kempen, 2018). The rating scale of difficulty is based on evaluative mechanisms, and little is known about its validity and metrical properties (Didier, s. f.). NineHeight develops and implements such an algorithmic formulation through supervised Machine Learning algorithms starting from a previous conceptual definition of the variables that influence this decision system. The 9H8 (*NineHeight*, s. f.) algorithm aims to extend the scope and increase the service functionality through harmonization, complementing the Standardized Interactive Systems (SIS) (*Gyms and Trends of 2017*, n. d.) (Beck-Doss, n. d.). To this end, it extrapolates the SIS concept to its application on any type of climbing scenario by creating objective knowledge to overlay, compare and contrast any situation on which a climbing sequence can be defined.

Methods: A sample of 1167 climbing sequences of between 3 and 10 nodes over 5 differents climbing surface configurations was used. These sequences, with a difficulty grade between 5+ and 8a+ (Draper et al., 2015) have been confirmed by climbers worldwide in 2.092.317 climbing attempts (97% attempts for grades between 6A+ and 7C+). All these sequences were graded without any a priori induced bias.

The degree of consensus is shown in the following table:

Grade	5+	6a	6a+	6b	6b+	6c	6c+	7a	7a+	7b	7b+	7c	7c+	8a	8a+
Consensus rate (%)	93,28	89,82	91,75	91,93	91	89,51	85,24	87,55	81,79	87,5	81,49	87,62	79,26	79,16	74,58
+/- 1 grade (%)	0,03	0,06	0,01	0,1	0,12	0,08	0,04	0,22	0,62	0,11	0,24	0,8	0,3	1,86	2,94

Table 1 Consensus rate by difficulty grade

The following methodology was applied from the sample stored in the NineHeight data base.

First: All the variables (dimensions) involved in the difficulty of a climbing sequence were identified:

- Spatial distribution of the sequence: The spatial arrangement of a series of nodes provides the necessary information to define the interrelation, distances, and relative position of the nodes in a three-dimensional hyperplane (X, Y, Z).
- Angle: If the nodes are located on the same surface, they acquire the same value in this variable. If their installation angle varies, this angle is taken into account to correct its impact on the sequence.
- Cumulative path: It is determined from the map with the spatial organization of the nodes, interpolating the initial, intermediate, and final positions, and thus, obtaining a specific graph for each sequence. This factor increases exponentially as the relative distance between the start node and the end node increases, as well as it does with less linearity in the distribution of the intermediate nodes.
- Relative value of the node: magnitude acquired by each of the nodes in a sequence. The sample is compossed by 7798 holds, classified as 189 characteristic node identifiers distributed trougth 1167 sequences. Each element is classified and coded with its own identifier according to:
    - Absolute value of the node, calculated by combining the following criteria: type of node (crimp, jug, sloper, pinch, micro, pocket, volume, tufa, crack) (Fuss & Niegl, 2006; Shea et al., 1992), the contact surface (regarding width and deep as number of fingers and phalanges in contact), and the shape of the node (smear, flat, edge).
    - Node orientation: Defined as the different combinations established by laterality and verticality criteria and conditioned by the shape of the nodes related to the spatial distribution of the sequence (Testa et al., 1999).

Second: Measurements of these standardized variables were created following a Delphi method with a panel of experts in climbing, mathematics, and biomechanics of sport with proven experience.

- Spatial distribution of the sequence: coordinates of nodes in three-dimensional tensors.
- Angle: Angle of inclination of each node represented in the sequence.
- Cumulative path: Three-dimensional Euclidean distance accumulated by interpolation between start and top (mandatory) given an intermediate distribution of nodes.
- Relative value of the node:
    - Absolute value of the node: Calculated by combining the criteria using hierarchical multi-criteria techniques.
    - Node orientation: Calculated using multi-criteria outranking techniques. They have been established based on the four cardinal points (N, S, E, W) and their combinations.

Third: The values of these variables were obtained for the 1167 sequences and two supervised Machine Learning algorithms were applied to obtain the relationship between these variables and the agreed difficulty of each sequence. Both algorithms were tuned in their parameters to obtain the most accurate predictor of the difficulty level according to the variables described above. The data set was not split in training and test sets due to its relatively small size and the use of bootstrapping sampling technique that allows testing results in non-selected sequences in each sampling iteration. The analysis was performed by the number of nodes in the sequences, thus from the sequences non selected in each bootstrapping step, the model was tested in those sequences less representative of the difficulty grade and, therefore, predictions were applied to these extreme values.

Results: 53% of the sequences analyzed had a consensus difficulty of less than 6C+, while less than 2% were considered grade 8 or higher as shown in the following table:

Grade	5+	6a	6a+	6b	6b+	6c	6c+	7a	7a+	7b	7b+	7c	7c+	8a	8a+
Number of sequences	33	32	79	68	127	144	144	132	109	80	56	86	55	16	6
Percentage (%)	2,82	2,74	6,76	5,82	10,87	12,34	12,34	11,30	9,34	6,85	4,80	7,36	4,71	1,37	0,51

Table 2 Number of sequences by difficulty grade.

The accuracy of the model was 99.99% in the whole sample, but the table below shows the average accuracy in these extreme values excluded in each bootstrapping iteration due to model overfitting:

Number of nodes	3	4	5	6	7	8	9	10
Modal difficulty grade	N/A	7C+,6C+	7C+,6B+	7A+,6C+	6B, 6B+	6C,6C+	6B+,6C+	6B+,6C
Accuracy on new extreme values	N/A	17,86	18,7	21,99	14,91	18,18	11,76	15,79

Table 3 Average accuracy of extreme values from bootstrapping resampling.

The lower row shows this overfitting. Since the model explains the sample with high accuracy, for each number of nodes, there is a high percentage of error in extreme non-selected sequences. This is because in each subset by the number of nodes, the two most observed difficulty grades make up to 30% of the subset, thus, new extreme values (sequences from grades very different from the most observed) are wrongly classified. This drawback can be overcome when the sample increases in size at very low and very high grades (different from the modal difficulty grades).

Conclusion:

The method proposes an objective classification of the difficulty of the sequences with a certain margin of consensus, although it is necessary to balance the observations and collect more samples of sequences of the less observed difficulties to avoid overfitting and the predictions being biased towards the most observed grades, normally corresponding to the lowest and highest grades, which are also the ones with the lowest consensus. In addition, it has been identified that the most important factor in determining the difficulty of a sequence is the node value in accordance with the study of López-Rivera (2012) and Katsura et al (2021).

The dichotomisation between the environment (nodes and sequences) and the individual (biomechanics and execution model), is argued through the results obtained in the present study, in which the variables considered for the estimation of the difficulty are not related to the definition stage of the athlete. Considerations regarding environmental conditions (humidity and temperature) or hold degradation (matrial grip) were not considered due to the lack of data related to them. With sufficient experience, this algorithm would be able, in addition to assigning the difficulty of a sequence, to solve it taking into account specific key characteristic of the athlete.

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A ROBOT FOR CLIMBING SPECIFIC FINGER STRENGTH ASSESSMENT AND TRAINING WITH REDUCTION IN SHOULDER LOAD

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Abstract

Climbing-specific finger strength training and assessment are commonly performed with a hangboard, which creates high loads on the shoulder joint. These high loads can be problematic for climbers who suffer from shoulder injuries. We propose a robot that creates the force on the fingers via a linear actuator. The counter force is in part created by a palm rest, thereby reducing the load on the shoulder. In a feasibility trial with experienced climbers, maximum voluntary contraction (MVC, N_{MVC} =9) and intermittent contractions (INT, N_{INT}=7) were performed with the robot, as well as with an instrumented hangboard with visual feedback. The MVC assessed with the robot was lower than with the hangboard, although the difference was not statistically significant and the MVCs were correlated ($R^2 = 0.63$, $p < 0.05$). Desired force tracking performance during INT decreased compared to the instrumented hangboard, but the difference was not statistically significant. During MVC, shoulder load was reduced by up to 99% during, yet by just 15% in the worst-case repetitions. Thus, robotic finger training and assessment with reduced shoulder load is possible, which might be of benefit to climbers suffering from a shoulder injury. However, proper utilization of the palm rest is important.

Keywords: fingerboard, hangboard, shoulder injury, haptics, rehabilitation

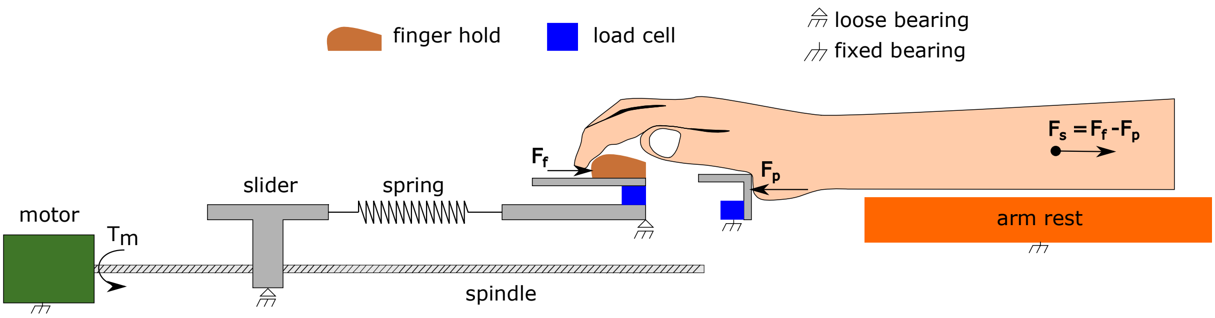

Figure 1. Mechanical concept of the robot. The motor drove the spindle with the torque T_m. The spindle drove the slider which pulled on the spring. The spring pulled on a plate connected to the finger hold. The hand palm rest is connected to the base of the robot (not shown). Load cells measured the finger force F_f and the palm rest force F_p. Linear potentiometers (not shown) measured the finger hold position.

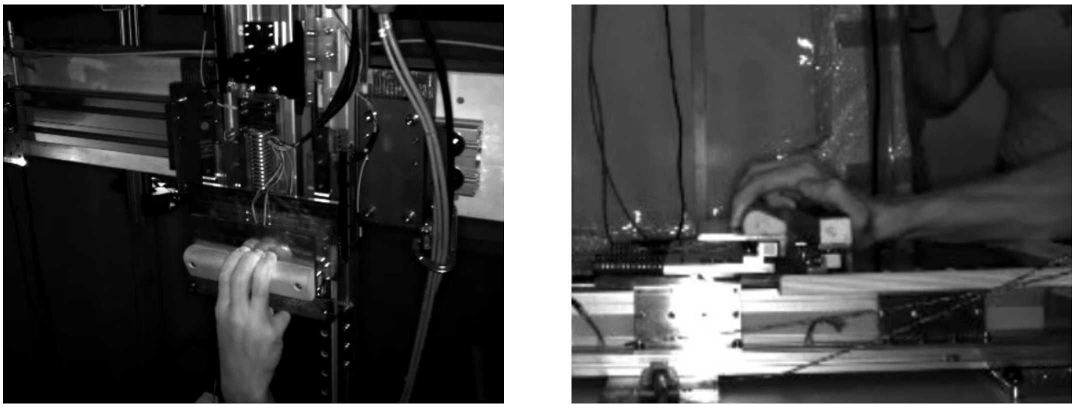

Figure 2. Left: *Hangboard condition* with the finger hold fixed and the robot mounted vertically. Right: *Robot condition* with the robot fixed horizontally on a table and a palm rest to create a counter force.

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Video

https://www.youtube.com/playlist?list=PLAybb2NYODZa1SwtStXKCOSkhkt9eEFTC

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PERFORMANCE ANALYSIS IN SPEED CLIMBING: FIRST INSIGHTS INTO ACCELERATING FORCES DURING STARTING PHASE

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Abstract
While athletes are constantly challenged by newly set routes in bouldering and lead climbing, athletes climb on a standardised route in speed climbing. This discipline is therefore ideal for analysing interaction forces between athlete and holds to train for optimal propulsive forces. In the present work, such an analysis was carried out.
The first footstep and the first three handholds of the speed route were instrumented with force moment sensors. The start pad on the ground was replaced by a force plate. Eight elite climbers performed the starting phase in in five different conditions: their usual start (i), with a counter movement (ii), and in conditions in which the lower left foot was shifted parallel to the wall (iii-v). The more experienced the athlete, the closer the directions of the mean forces measured at hands and feet were to each other, i.e., forces added up in magnitude instead of cancelling each other out. By manipulating the foot position, the direction of the mean force could be changed by up to 30° in a plane parallel to the wall. Our visualisation of forces may allow for intuitive access for athletes and coaches to optimize the starting phase in speed climbing.

Keywords: instrumented climbing holds; biomechanics; impulse

Introduction

Interaction forces between a climber and holds are essential for successful climbing. Although several research groups have meanwhile developed instrumented climbing holds (e.g., Fuss & Niegl, 2006; Maffiodo, Sesana, Gabetti, & Colombo, 2020; Pandurevic, Sutor, & Hochradel, 2020), at present it seems that mainly force data obtained with instrumented hangboards or single holds can be used meaningfully to adjust training measures or to optimise performance. That not more work has been done with even more climbing-specific tasks may be due to the facts that instrumenting an entire route is expensive and that the routes in bouldering and lead climbing are constantly changing, which makes it quite challenging to compare and identify optimal force profiles. In contrast, speed climbing is characterised by a standardised route, which makes this discipline an ideal research subject.
First insights into the dynamics of speed climbing were gained 15 years ago by Fuss & Niegl (2006) in which climbers performed at three different speeds of ascend. A positive correlation between climbing speed and contact forces as well as maximum impulse was found. However, the official standard route has changed since then. Braghin, Cheli, & Maldifassi (2012) suggested that the explosive force of the lower extremities is the essentially

factor that determines performance. They measured the contact forces, but due to an additional frictional connection in addition to the sensor, results should be interpreted with caution. In principle, therefore, little knowledge exists on contact forces in speed climbing, and on how those forces differ between athletes and how they can be modulated, e.g., by starting techniques.

To the best of our knowledge, the presented study is first to report on the contact forces which occur during climbing of the official speed climbing route of the International Federation of Sport Climbing (IFSC speed license rules, version 4-1, March 2014). We instrumented four holds and the starting pad, for precise measurement of the contact forces during the starting phase. In addition, we manipulated the position of the left foot standing on the ground to see to which extent we can manipulate the direction of the forces and the summation of the forces.

Methods

The experiments were carried out in a public climbing gym (Griffig, Uster, Switzerland). Two panels of the existing climbing wall were exchanged by custom panels with the force instrumented holds (Figure 1). The first three hand holds, as well as the first foothold of the route were equipped with a multiaxial instrumentation composed of three piezoelectric force sensors (9251, Kistler AG, Switzerland) enabling measurement of interaction forces with a range of ±7.5 kN in the plane of the wall and of ±15.0 kN perpendicular to the wall (Simnacher, Spoerri, Rauter, Riener, & Wolf, 2012).

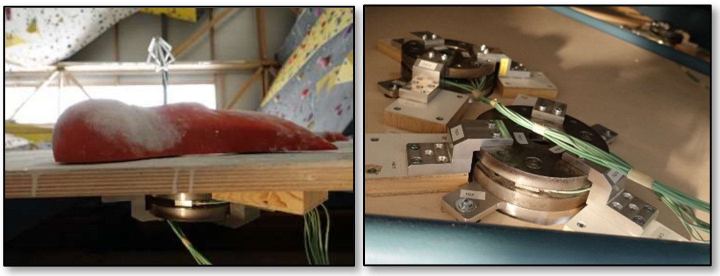
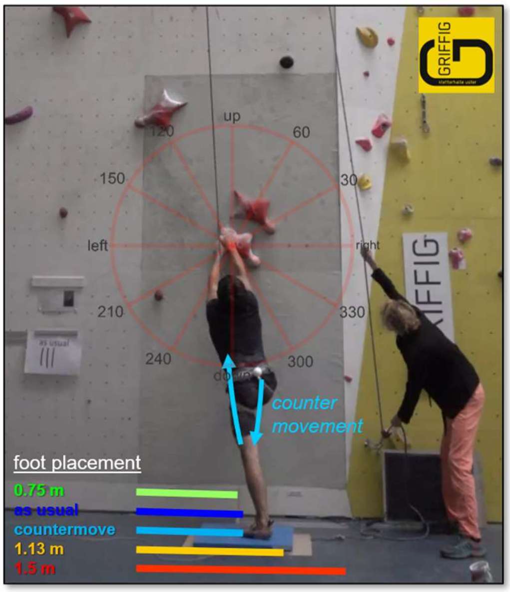


Figure 1. Instrumentation of holds. Left: View from underneath the panel, looking up to the ceiling. Note the small gap between the hold (red) and panel (wood and grey coating). The gap guarantees that all forces were transmitted

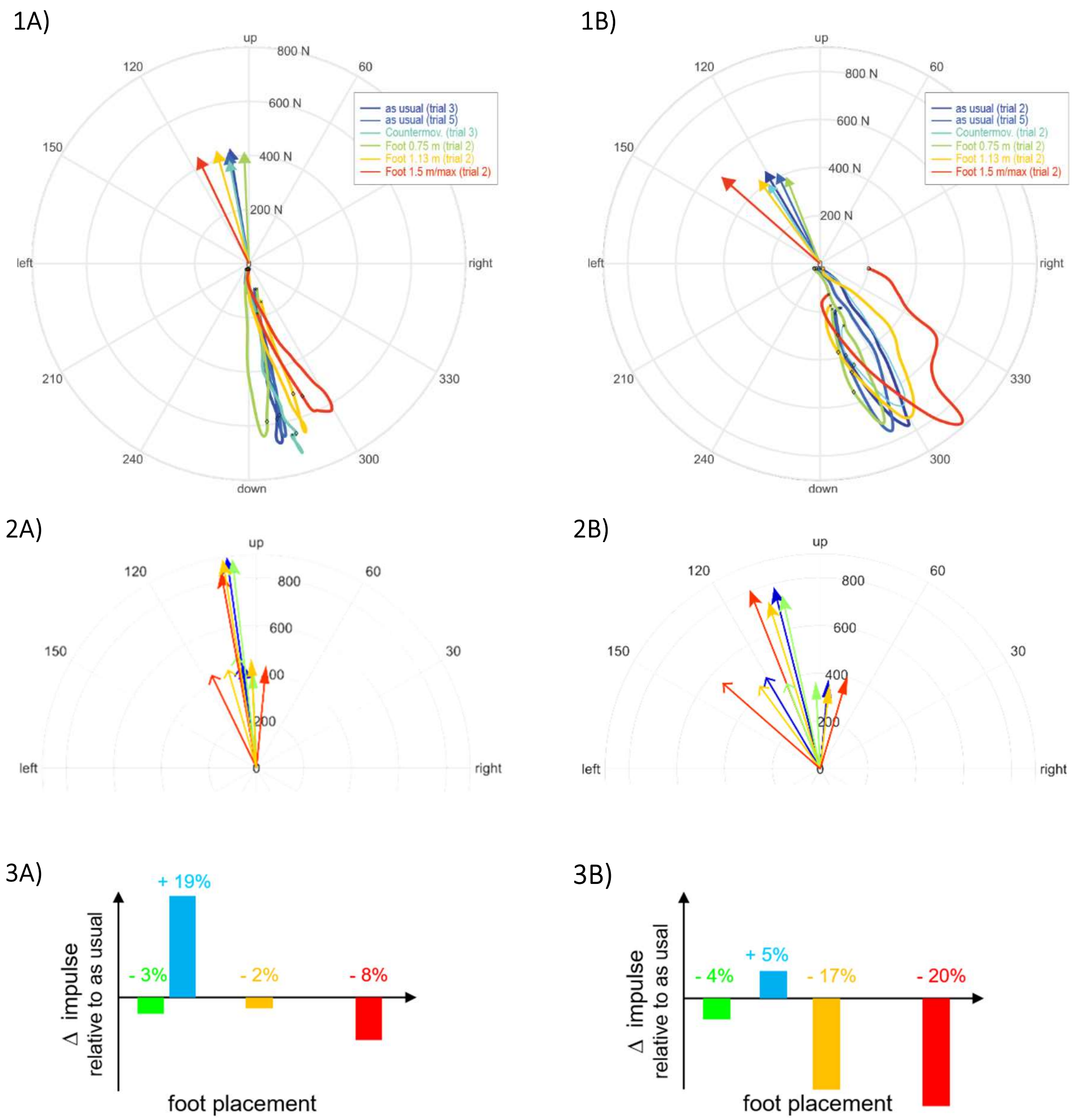


via the sensor but was small enough to not affect the climber. Right: Right: View from behind the wall with the instrumentation (metallic) mounted to the backside of the panel (bright wood).

Figure 2. Starting position. The different foot placements are indicated with the color code used in the results.

The instrumentation was not perceivable to the climbers, due to the high stiffness and minimal gap between the hold. The coating of the panel and the acoustic start signal were realized according to IFSC regulations (given in 2019). The starting pad on the ground was replaced by a force plate (Type 9260AA6, Kistler AG, Switzerland). Eight climbers of the Swiss elite and junior national squad participated in the study, all with experience in speed climbing competitions at national or international level. Five different starting conditions were chosen: the way they usually did it, which was in most cases without a countermovement (i, six repetitions over two blocks), with a counter movement (ii, three repetitions) and with the lower left foot at three defined locations (iii-v, see Figure 2, three repetitions each). The experiment started with and ended with the "as usual" condition; the order of the other conditions was randomized. The athletes were asked to climb up to the seventh big hold, 1.5 min breaks after each trial, 3 min break after each condition, additional 12 min break after every second condition. The study was approved by the Ethic Commission of ETH Zurich (EK 2019-N-31) and the participants gave their written consent.

Results & Discussion



Two elite climbers (A, B) compared as examples. *1A & 1B*: Forces (in N) applied at the lower starting handhold in the plane of the wall (curved lines) and as mean reaction force (arrow) of representative trials. If the development of the force covered a larger area, the direction of the force application changed more (athlete B), which might not be optimal. *2A&2B*: Mean reaction forces at start hand grip (open arrowhead), at right foot as well as in total are shown. In the "usual" condition, forces added up optimally for athlete A whereas for athlete B the forces already acted in different directions by 30°. *3A&3B:* The impulse effective against gravity for the different foot placements. Bar of the counter movement (light blue) is placed relative to the other foot placements at 0.75 m (light green), 1.13 m (yellow) and 1.5 m apart from the left boarder of the panel replaced (see Figure 2). Unusual foot placements resulted in lower impulse compared to the "usual" foot placement. A greater impulse was achieved with the rather unfamiliar counter movement (however, the impulse was also needed to lift the body again).

Conclusion

Our analysis of forces an athlete applies during the starting phase of speed climbing under almost competition-like conditions provided new insights for evaluating and improving the athletes' technique. Using a counter movement coordinated with the anticipatable start signal should be aimed for, as it generated a greater propulsive impulse than the condition usually used by the athletes at the time of the measurement. In further exchange with coaches and athletes, it is now a matter of processing this initial data and subsequently repeating the measurements in such a way that training measures can be formulated.

Acknowledgements

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ACCEPT – A SENSORIZED CLIMBING WALL FOR MOTOR REHABILITATION

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Abstract

We are designing a novel set of sensors optimized to be inserted in a climbing wall, and we are optimizing the wall and holds geometry for usage in training as well as rehabilitation. In this abstract, we illustrate preliminary results on the design of a version of this wall, called ACCEPT, optimized for use with children with cerebral palsy.

Keywords: Sport climbing; force sensors; cerebral palsy.

Infantile cerebral palsy (ICP) affects over 17 million people in the world. In most cases it is caused by cerebral lesions occurred during pregnancy, and it is diagnosed in the first 12-18 months of life. Spastic hemiplegia, where one side of the body is affected, is the most common type of ICP (over 40 % of individuals); a precise diagnosis usually occurs within the first 3-4 years of life. At the moment, there is no cure for ICP. Recommended therapies for children and young adults consist in rehabilitation programs adapted to age (physiotherapy, psychomotricity, speech therapy), integrated with activities to be performed in the family environment. This type of treatment is fundamental to allow an adequate functional recovery of the involved brain areas, and to stimulate brain plasticity (ability of survived nerve cells to replace the function of the lost ones). By means of a proper rehabilitation program, especially if started very early in life, it is possible to recover part of the motor abilities and attenuate the effects of ICP.

The inclusion of sport climbing as part of the activities involved in the daily rehabilitation of children and young adults with ICP has been already considered in some studies (Christensen, M. S., Jensen, T., Voigt, C. B., & Nielsen, J. B., 2017). Sport climbing is a highly symmetric activity suited to engage the plegic side of ICP subjects. It is also physically and mentally challenging, which helps counteract the mental and motor compensation schemes that ICP subjects rapidly develop to conduct routine tasks.

In the ACCEPT – Adaptive Climbing for Cerebral Palsy Training project, which we are carrying out at Politecnico di Milano and in collaboration with the FightTheStroke foundation, we are designing an innovative, adapted and sensorized climbing wall optimized as a playground in rehabilitation activities for children with ICP.

The project aims to design the adaptive sensorized wall from the ground up, using a Human-Centered Design (HCD) approach based on inclusive design principles. Starting from solutions on the market, such as the Everlast

Adaptive Climbing Wall, and lab experiences such as those reported in (Fuss & Niegl, 2008), a multidisciplinary research team studied the needs and desires of the users (sport climbing instructors, physiotherapists, people with disabilities, climbing hold manufacturers, climbing gyms) through co-design sessions organized with the qualified staff of the FightTheStroke association (Association of families of children with CP) and the other stakeholders. The complexity of the project required bringing into play different skills, ranging from the design of the sensors and the climbing wall (mechanical, electronic, IT, design and ergonomics) to the medical and social knowledge necessary to involve children and to follow and guide them in the climbing activity. During the co-design sessions, the experience of the involved professionals and stakeholders allowed to define the anthropometric and ergonomic requirements in terms of grips modularity, protrusions and proprioceptive inputs (colors, textures, sounds and lights) that help to improve sensory integration and to identify effective methods of analyzing the interaction between children and the ACCEPT wall.

The ACCEPT wall, as conceived in the context of this project, is a bouldering wall approximately 3.6m wide and 2.5m tall, with an inclination that can be set between +10 and -10 degrees from vertical. A regular grid of standard M10 bolt sockets arranged approximately 25cm from each other to fix the climbing holds. The central part of the wall is fully sensorized: each socket can be equipped with a 3-axial force sensor.

The force sensors are custom-designed (patented) and based on strain-gauge measurements, with shape optimized to integrate into the climbing wall and provide a front face that is functionally indistinguishable from that of a standard climbing wall. The sensors can measure the three components of a force vector in the range from ~4 to 2400kN, independently of the point of application of the force on the hold. This allows us to obtain consistent results using holds of arbitrary shape (though with some constraints on the total diameter).

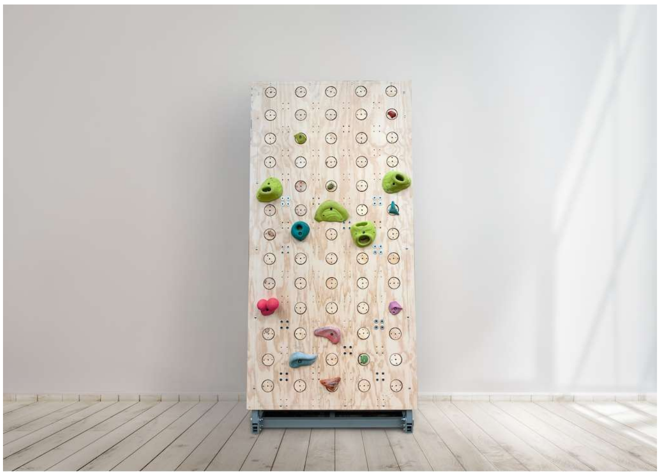

Figure 1: the central part of the climbing wall. The discs conceal force sensors.

The sensors, which take the role of the wall panel inserts in supporting the climbing holds, are designed to comply with norm EN 12572.

Each sensor is equipped with a dedicated acquisition board with a sampling rate of 80Hz, mounted near the sensor to minimize electromagnetic interference. All acquisition boards communicate over a common bus towards an edge node, which aggregates data from all the sensors and sends it to a receiving app, which can currently be on laptops or an iPad. In each acquisition board, crystal oscillators and a synchronization algorithm ensure a temporal drift between data streams from different sensors estimated below 10ppm, so that we can combine force signals from different sensors with minimal processing, without the need to align the data streams.

We are currently in the process of optimizing the electronic components of the acquisition boards and the software infrastructure, from the communication protocols to the user interface, and we are planning to run the first full-scale tests, with a group of children, in the second half of 2021. We have however completed a first batch of tests with adult subjects, with the objective of verifying the basic functionality of the sensors.

The testing procedure consisted of a short warmup session off the wall, followed by the repetition of a fixed climbing sequence, depicted in Figure 2, on the sensorized climbing wall with vertical inclination, with mandated hand movements and free feet movements. The climbers had never tried the sequence before stepping on the wall.

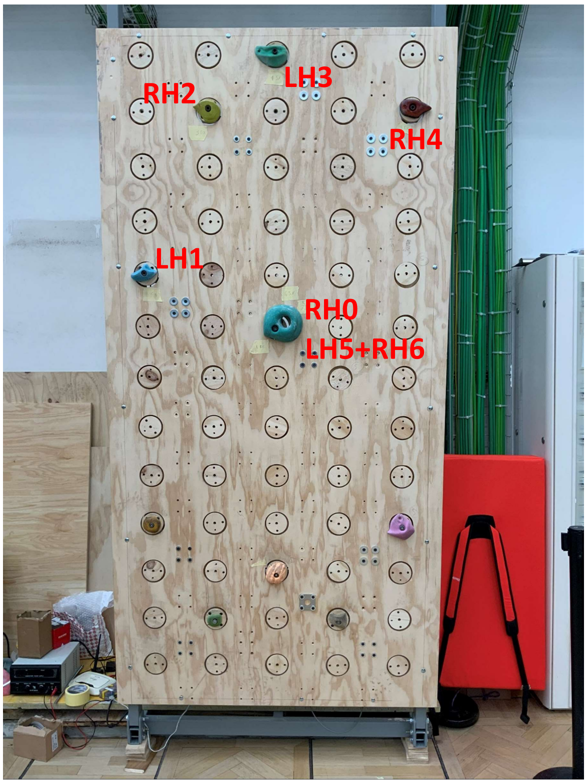

Figure 2: the climbing sequence. Moves on the bottom 5 footholds were free, while handholds where fixed. The circuit started with right hand on RH0, left hand on LH1, then proceeded in order with right hand on RH2, left hand on LH3, right hand on RH4, left hand on LH5, right hand on RH6, left hand on LH1. This was the starting stance, and the circuit was iterated as long as the athlete could endure.

Figure 3 displays an example of the data obtained from the sensorized climbing wall:

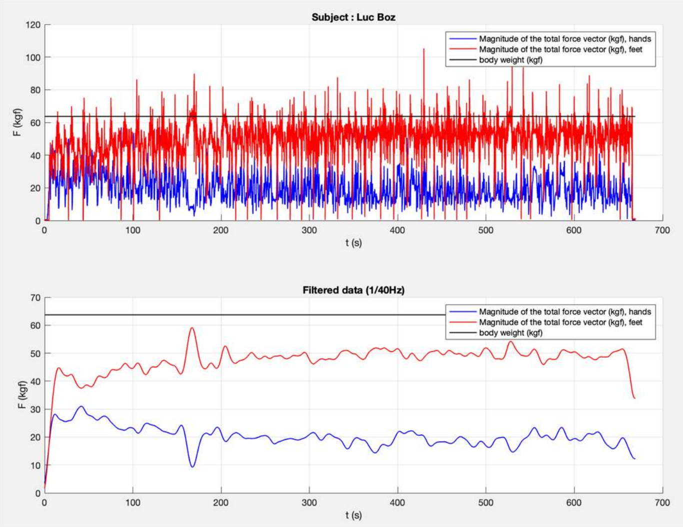

Figure 3 : example of the data obtained from the sensorized climbing wall

The blue and red lines represent the magnitude of the vector sum of the forces on handholds, and on footholds, respectively, while the black line is the test subject's body weight, measured on a commercial scale before stepping on the wall.

The top panel displays the data as it is received from the sensors, while the bottom panel shows the same data fed through a 1/40Hz filter. On this and most other subjects in our batch of tests, we can see an upward trend in the total force exerted on the footholds, and a downward trend in the total force on the handholds, in the first 5 minutes of climbing. We hypothesize that this trend is related to the subject learning the route and optimizing movements towards more efficient use of the lower vs upper body, consistently with the results discussed in (Baláš et al., 2014) While this is, of course, just a preliminary validation of the functionality of the wall, we believe the results are promising. The fact that the sensorized wall appears to the user as a standard climbing wall simplifies its usage in public spaces and should ease its acceptance as a training tool for athletes and a tool for motor evaluation and rehabilitation. We are currently in the process of setting up the full version of the ACCEPT wall in a public sports center in Milan, and we have partnered with climbing hold manufacturers to develop holds specially designed for the rehabilitation purposes of the ACCEPT project. Though the route is still long, we believe we are taking a step towards making quantitative measurement in sport climbing more accessible and hopefully making sport climbing a more inclusive activity, suited to the passionate climber and people with motor disabilities seeking a more engaging approach to rehabilitation.

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Day 3 - Session 1

OBJECTIVE CLIMBING GRADES ARE PRACTICAL AND USEFUL

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Abstract

Conventional grading systems for rock climbing routes assign a difficulty grade to a route based on the opinions of a few people. This methodological paper defines a difficulty rating using an objective measure: the negative expected log-odds of success across all ascents of that route, which has an interval scale. Previous research demonstrates that ratings can be estimated using a Bradley-Terry statistical model. Climbers are already logging the necessary data: "theCrag" (a climbing website) has a database of hundreds of thousands of ascent records across tens of thousands of routes. Difficulty ratings using this new definition provide climbers and researchers with several advantages over conventional grades, including an empirical methodology for revising ratings as new evidence becomes available, and the use of statistical methods requiring interval scales.

Keywords: Bradley-Terry model, difficulty rating, grAId

Acknowledgements: The author thanks the staff of theCrag Pty. Ltd. for their assistance.

Introduction

Climbing grades give an indication of the difficulty of a rock climbing route. Conventional grading systems around the world (including UIAA, French, YDS, Ewbank) rely on subjective factors, and grades are usually assigned by just the climbers that first ascended a particular route (Draper, 2016). Draper et al. (2016) proposed the IRCRA Reporting Scale for use in climbing research and statistical analyses, but it is unsatisfactory for this purpose: like the systems it is based on, it is subjective, ordinal, and lacks formal criteria for each grade.

There is existing research into using the holds on a standardized training board to classify routes into conventional grades (Dobles, Sarmiento, & Satterthwaite, 2017; Duh & Chang 2021; Tai, Wu, & Hinojosa, 2020). Of these, Duh & Chang's classifier was the most accurate: 84.7% of route predictions were within 1 unit of human-assigned grades on the Hueco scale. However, these approaches are not practical for routes where the holds and their positions are not standardized. Kempen (2018) used a language for describing holds and sequences of moves, but Kempen's classifier barely outperformed a random classifier with only two grades (easy and hard). In all these studies, the use of conventional grades as the measurement of difficulty replicates the same drawbacks as previously discussed: reliance on a relatively small number of expert opinions (for model training and validation) and an ordinal output scale with no objective definition.

This methodological paper addresses these shortcomings by defining an objective route difficulty rating on a formal, interval scale. It summarizes previous research regarding a practical methodology for empirical ratings estimation. Finally, it describes how these ratings are useful to researchers and climbers.

Definition

Climbing ascents can be classified as "successes" or "failures". A common definition of success for sport climbing is free-climbing the route from start to finish. This definition can be applied in an objective fashion by the climber or an observer. The probability of success depends on factors including the performance of the climber, the route and the conditions. This probability is one way of measuring difficulty: a smaller probability of success indicates a more difficult ascent.

Define the *route difficulty rating* (hereafter, "rating") as the negative expected log-odds of success across all ascents of that route. Equivalently, the rating is the expected log-odds (without negation) of failure for the same ascents. This averages the outcome across all combinations of factors affecting success. The rating has a continuous, interval scale: a unit increase in the rating corresponds to an odds ratio of *e* (the mathematical constant). The rating increases with the difficulty of a route: even odds of success correspond to a rating of zero, while a one in 60,000 probability of success corresponds to a rating of approximately 11. This is an objective, quantifiable measure. While the rating is defined in terms of a random variable that cannot be directly measured, the next section describes how it was practically estimated.

Estimation

Ratings have been estimated empirically for thousands of outdoor routes, using objective observations. There are three practical considerations for estimation: data of sufficient volume and quality, an accurate statistical model for estimating ascent success, and software that can estimate the parameters of the model without prohibitive computational resources.

Previous research by Scarff (2020) met these practical considerations. Scarff used Australian ascent records from "theCrag", a website where recreational climbers self-report ascents. After pre-processing, the dataset consisted of 236,096 ascents by 3,000 climbers over 8,917 outdoor sport routes. Each ascent record consisted of an outcome (successful or failure), route, climber and date. The failure rate was 27%. Scarff used a dynamic Bradley-Terry model, which predicts the log-odds of success to be the climber's performance rating at the time of the ascent minus the route's difficulty rating. The route difficulty rating is consistent with the previous definition, assuming a hypothetical population of ascents with a mean climber performance rating of zero. Scarff computed ratings using the Whole-history Rating algorithm, which uses Newton's method to estimate the maximum a posteriori ratings (Coulom, 2008). Fitting this model was cheap: the software was (and continues to be) free and open source, and it estimated the ratings parameters in less than a minute using commodity computer hardware.

An advantage of this method is the simplicity of its input data. In contrast to other machine learning approaches to classifying climbing route difficulty (Dobles, Sarmiento, & Satterthwaite, 2017; Duh & Chang 2021; Kempen, 2018; Tai, Wu, & Hinojosa, 2020), there is no need to record and categorize individual holds or moves. However, log-odds ratings could be used as the output of such models, which would offer the advantages of an objectively defined interval output scale.

Volume and quality of data are a concern. While large-scale data sources such as theCrag exist, their data are proprietary. Furthermore, there are quality concerns with self-reporting, particularly around under-reporting of failed ascents. The quality concern could be addressed by recording ascents under supervision or with quality control methods, but it is not practical to do that at the same scale.

Correct and reproducible estimation depends on assumptions about the set of "all ascents" and what constitutes a route. If this set includes any hypothetical ascent made by any climber in the world at any time, then the rating is *universal*: it does not depend on geography or time. However, a sample of ascents by local climbers may not be representative of the universal set, and the performance of climbers in a particular time period may not reflect the performance of future generations of climbers. A successful ascent is more likely if the climber has previously succeeded at ascending the route; excluding these repeat ascents will increase the difficulty rating. If a hold breaks on a route, it may affect the difficulty and therefore constitute a distinct route. Researchers should choose definitions and assumptions that suit their application.

Applications

Route difficulty ratings can be useful to researchers. They have a formal, objective definition. Ratings can be used with statistical techniques that require continuous, interval scales, such as the response variable in a linear regression. The log-odds scale has a mathematically elegant zero (even odds), units (based on the natural logarithm), and symmetry (log-odds of failure are the negated log-odds of success). For research purposes, these are all improvements over the IRCRA and other conventional scales.

A dynamic Bradley-Terry model is a practical method for researchers to estimate ratings. This model defines a formal, probabilistic relationship between route ratings and climber performance. Variance estimates generated by the model measure the uncertainty of ratings estimates. Finally, the model can be used to generate falsifiable predictions about ascent outcomes. Again, these are all improvements over the IRCRA scale.

Route difficulty ratings are not limited to a particular model. Researchers can use ratings models developed for other sports. For example, they can use Glicko-2 (Glickman 2013) to model changing volatility in climber performance. Alternative models can also incorporate additional predictors, such as climber characteristics (e.g., height, performance on standardized testing), conditions (e.g., temperature, humidity), or attributes of the route (e.g., permitted holds on standardized training walls). All models that predict ascent success can be empirically evaluated and used to estimate route difficulty ratings.

The ratings can also be useful to climbers. Grades derived from Scarff (2020) have been published on theCrag's website under the brand name "grAId" (theCrag, 2021). To make grAId more familiar to climbers, it is presented on conventional grade scales rather than as log-odds. The log-odds rating was transformed to theCrag's Climber Performance Rating (CPR) scale (Dale, Heywood, Hochmuth, & Fuchslueger, 2018) using a linear transformation, and from the CPR scale to conventional scales using a non-linear mapping. The grAId is only published for routes with conventional grades less than Ewbank grade 29, and where the estimated variance is less than a threshold. The grAId is published on more than 32,000 routes, including sport, trad and bouldering styles. This free resource provides a complement to conventional grades that is widely accessible and updated continuously using empirical evidence.

Climbers and researchers must understand that route difficulty ratings may not be consistent with conventional grades. Scarff (2020) found only weak correlation between ratings and Ewbank grades ($R^2 = 0.640$), and users on theCrag anecdotally disagreed with some grAId estimates. The absence of formal criteria for other systems makes it unclear what they measure, but factors include the perceived effort and technical proficiency required for success. While these factors may be related to the probability of ascent success, they are not equivalent.

Applications requiring objectivity, empiricism or interval scales will benefit by measuring difficulty using the methodology described in this paper. Conventional systems retain the advantage of being widely used, despite their subjectivity.

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PERSONALITY, GRIT, AND PERFORMANCE IN ROCK-CLIMBING: DOWN TO THE NITTY-GRITTY

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Abstract

Over the past decades, the study of personality elicited the interest of sport psychology, an example being performance in extreme sports explained through the lenses of sensation seeking. The aim of the present study was to identify how personality traits are connected with various facets of climbing performance, by investigating for the first time, the impact of Grit as a psychological predictor of performance on outdoor bouldering and sport climbing. Our sample included adult participants from 34 countries ($N = 272$ sport climbers, 155 boulderers) with ages between 16 and 69 ($M = 32.1$, $SD = 10.0$). We measured: climbing ability and personality (Big Five Inventory FFM –2 Short Form, and Grit). Results indicated that Grit predicted climbing performance over and beyond the FFM traits. Contrary to the commonly held view depicting Grit as nothing else but Conscientiousness, our findings suggest that this trait has a unique contribution to explaining performance in climbing, a sport requiring persistence in attaining long term objectives.

Keywords: personality; Grit; climbing; bouldering; performance

Acknowledgements: we thank the Exercise & Sport Psychology group from Babes-Bolyai University for their support.

Introduction

Personality is one of the most seminal areas of psychological research, covering a broad range of domains. Recently, also sport psychologists and researchers turned their attention to understanding how personality impacts various aspects of sport practice and athletic performance. Most of the extant research suggests that out of the FFM traits, mainly Neuroticism and Conscientiousness are consistently related with various aspects of sport-related practice and performance (e.g.: Allen, Greenlees, & Jones, 2013; Laborde, Allen, Katschak, Mattonet, & Lachner, 2020; Waleriańczyk, & Stolarski, 2021). However, little is known about how personality traits come into play in practicing and performing sports having a higher degree of mental and emotional load, such as high-risk sports.

High-risk sports, such as rock-climbing have been steadily increasing in popularity (Clough, Mackenzie, Mallabon, & Brymer, 2016; Brymer, Feletti, Monasterio, & Schweitzer, 2020; Crust et al., 2020). FFM traits appear to be relevant for the practice of these sports. McEwan, Boudreau, Curran, and Rhodes's (2019) review reported that Extraversion had a significant association with participation in extreme sports. Tok (2011) also reported that sensation seeking, and Extraversion were positively related with high-risk sport participation.

To date, little is known about how FFM traits or other lower-order personality dimensions impact performance in high-risk sports. We could not identify any empirical study exploring how personality traits relate to performance in outdoor sport climbing and bouldering. A recent investigation explored how personality traits and sensation-seeking relate to climbing in a sample of participant labelled as "competitive" climbers: boulderers, sport climbers and traditional climbers taken together (53% outdoor climbers), although these practitioners were not involved in organized competitions. In this study, Rumbold, Madigan, Murtagh-Cox, and Jones (2021) did not measure any performance indicators, but focused on identifying specific personality profiles for "competitive" climbers. They employed four personality profiles: Healthy, Emotionally Unstable, Measured and Compliant, Curious and Impulsive.

However, more research is warranted in order to capture a potentially intricate relationship between FFM traits, narrow personality dimensions and the practice and performance in high-risk sports. Consequently, we turned our attention to those narrow personality traits related to long-term achievement. One such dimension is Grit, defined as "perseverance and passion for long term goals" (Duckworth, Peterson, Matthews, & Kell, 2007, p. 1087). Extant research suggests that Grit plays a non-trivial role in various athletic endeavors, sport-specific Grit having a significant association with athletic identity (Mosewich, Dunn, Causgrove Dunn, & Wright, 2021). Grit moderated the relationship between motivational feedback and subsequent athletic performance (Moles, Auerbach, & Petrie, 2017). Moreover, Grit emerged as a significant predictor of sport-specific activities, including training, play, or participating in competitions (Larkin, O'Connor, & Williams, 2016). Considering Grit's relevance for attaining long term success in various aspects of human performance and also its connection with various aspects of mental functioning, such as flow or effortless attention, aspect that underlie athletic performance, we were surprised that we could not identify any empirical paper that investigated the direct relationship that Grit might have with sport-specific athletic performance. Only a few studies have previouslly showed that Grit, in the form of passion, is relevant for expert performance, rendering it as a personality trait that distinguishes elite athletes from non-athletes (From, Thomsen, & Olesen, 2020; Newland, Gitelson, & Legg, 2020).

Overall, analyzing the existing personality extreme-sport literature we observed the following: (1) most of the research has focused on understanding the relationship between broad FFM personality traits and the practice of extreme sports; (2) Extraversion and Neuroticism have non-trivial association with practicing extreme sports; (3) Practicing extreme sports was associated with narrow personality traits, more specifically sensation seeking and impulsivity.

The overarching objective of our investigation is to expand the current scientific understanding regarding the relationship between personality and performance in sport climbing and bouldering, two athletic disciplines considered extreme sports. Research question 1: Do FFM personality traits (Neuroticism, Extraversion, Openness, Agreeableness, Conscientiousness) predict performance in rock-climbing? Research question 2: Does Grit predict climbing performance over and beyond FFM personality (e.g., Neuroticism, Extraversion, Openness, Agreeableness, Conscientiousness)?

Methods

Participants

Power estimation. The optimal sample size necessary for detecting small effect sizes (.10 or larger), with a power of .80, was established via power analysis conducted with G-Power. The sample size necessary for detecting such effects was 159 participants, for a model including one criterion and eight predictors. For the purposes of this study, we collected data from 272 participants. The sample consisted of 272 adult sport climbers among them 155 boulderers, and 114 women (41,91 %) and 158 men, with ages between 16 and 69 (*M* = 32.13, *SD* = 10.01), and with years of experience between 10 months and 40 years (*M* = 9.02, *SD* 9.14). Most participants (120) had a bachelor's degree, 107 participants had a graduate or post-graduate degree, while only 14.34% had a high school degree.

Measures

Sport Climbing Performance. IRCRA Scale for self-report Climbing Ability was used for Sport Climbing and Bouldering ability (Draper et al., 2015). Participants were asked to self-report their Best three Redpoints, Highest Redpoint (all time), Highest Redpoint (12 months) – for Sport Climbing and Bouldering, also Highest Onsight in Sport Climbing and Highest Flash in Bouldering, from which we extracted an Overall Performance score.

Personality. Personality was measured based on the Five-Factor Model using the 30-item of the Big Five Inventory–2 Short Form (BFI-2-S; Soto & John, 2017). The five domains were measured with items rated on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree). Internal consistencies for the five dimensions ranged between .72 (Conscientiousness) and .82 (Neuroticism).

Grit. We used a two-dimensional 12-item inventory to measure Grit (Duckworth et al., 2007) which has shown very good psychometric characteristics (Duckworth & Quinn, 2009). Some example items are 'Setbacks don't discourage me' or 'I often set a goal but later choose to pursue a different one', measured on a scale from 1 (not like me at all) to 5 (very much like me). Internal consistency reliability as measured with Cronbach's Alpha was .79.

Procedure

The measures were administered via an online survey. The survey was disseminated via email and social networks to adult climbers from 34 countries between May and November 2020. The participants were required to be fluent in English in order to complete the survey. The participants were explained their rights as volunteers and all of them provided their informed consent before completing the survey. No incentives were offered in exchange for responding.

Results

Means, standard deviations, bivariate correlations between our main variables and internal consistency reliabilities (Cronbach's Alpha) are shown in Table 1. Next, we examined the predictive validity of the FFM dimensions and Grit over Education and BMI in predicting various aspects of outdoor sport climbing performance and outdoor bouldering performance, respectively. The results are reported in Table 2 and Table 3. In estimating the validity of the FFM personality dimensions and Grit in predicting performance in outdoor sport climbing and bouldering a hierarchical regression was employed. In Step 1, demographic characteristics were entered (Education and BMI). In Step 2 the FFM personality dimensions were included, illustrating their unique contribution in explaining the variance of sport climbing and performance dimensions. In Step 3, Grit was added in order to estimate its predictive validity over both demographics and the FFM dimensions.

Discussion

This study is the first empirical investigation of the relationships between personality traits and performance in rock-climbing and bouldering. Our research expands the already existing efforts of understanding how personality traits relate with physical activity and athletic performance. We analyze this relationship through the lenses of an extreme sport – rock-climbing – specifically, sport climbing and bouldering. Several key findings emerged: (1) the FFM dimensions do not predict performance in two distinct rock-climbing disciplines: sport-climbing and bouldering, although Neuroticism and Extraversion have been linked with participation in extreme sports (Tok, 2011; McEwan et al., 2019); (2) Grit consistently predicts different performance criteria in both sport climbing and bouldering, over and beyond BMI in what is regarded as a weight-dependent sport; (3) Grit has a higher utility compared with the FFM personality traits in predicting five different performance criteria in both sport climbing and bouldering.

Limitations

There are several issues that would warrant further discussion. First, our investigation relied on a cross-sectional design, where antecedents and outcomes are measured at the same point in time. This procedural design does not permit us to establish the direction of the influence. Reverse causal effects, such as personality changes caused by regularly practicing rock-climbing are viable hypotheses that cannot be tested in this design.

In this sense, further directions of research would include longitudinal designs and the inclusion of other possible outcomes, especially since the author of the scale has claimed that this personality construct can change over the course of a person's lifetime, as a result of effort, environment and others (Duckworth, 2016). Second, the results could be plagued by common method bias.

Conclusions

Understanding the way in which personality constructs, such as the FFM and Grit, can contribute to explaining the variance of climbing performance outcomes is an important steppingstone in establishing the practical values of these constructs. Finally, most of the associations above gravitate around Neuroticism and Conscientiousness, as the personality traits explaining performance in sports (Aidman, 2007). Taken together, our findings suggest that Grit is relevant and impacts climbing performance, rendering the construct an important predictor that explains climbing ability outcomes over and beyond the well-established personality dimensions.

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Table 1. Descriptive Statistics and Scale Intercorrelations

		M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Age	32.1	10.0	-																			
2	Education	14.5	5.3	.07	-																		
3	BMI	21.9	3.6	.11	.04	-																	
4	Experience	9.0	9.1	.69***	.02	.09	-																
	Sport climbing																						
5	Overall[1]	16.0	4.5	.15*	.10	-.07	.46***	-															
6	Best 3 RPs[2]	17.0	4.6	.19**	.10	-.05	.48***	.99***	-														
7	Highest RP[3]	17.3	5.0	.18**	.10	-.06	.48***	.98***	.98***	-													
8	Highest RP (12 mths)[4]	16.5	4.3	.08	.15*	-.14*	.35***	.94***	.91***	.91***	-												
9	Highest Onsight	15.0	3.7	.13	.09	-.07	.45***	.96***	.93***	.92***	.85***	-											
	Bouldering																						
10	Overall	10.9	9.9	-.03	-.01	.06	.14*	.34***	.43***	.34***	.35***	.35***	-										
11	Best 3 RPs[2]	19.5	4.1	.26**	.08	-.07	.48***	.59***	.68***	.59***	.61***	.66***	.98***	-									
12	Highest RP[3]	11.5	10.1	-.03	.00	.06	.14*	.35***	.44***	.35***	.35***	.36***	.99***	.94***	-								
13	Highest RP (12 months)	19.1	4.2	.18*	-.03	-.04	.33***	.42***	.48***	.42***	.48***	.50***	.85***	.77***	.72***	-							
14	Highest Flash	18.1	3.7	.21**	.07	-.06	.44***	.58***	.63***	.53***	.60***	.62***	.96***	.95***	.90***	.75***	-						
15	N[5]	15.5	5.1	-.13*	.02	-.06	-.13*	-.06	-.02	-.05	-.07	.01	-.04	-.17*	-.03	-.29***	-.17*	(.82)					
16	E[6]	20.5	4.4	-.05	-.03	.02	-.03	.06	.06	.04	.12	.04	.02	-.04	.02	-.04	-.03	-.25***	(.74)				
17	O[7]	23.0	3.9	.17**	.14*	.03	.08	.09	.12	.10	.12	.07	-.03	.09	-.04	.00	.09	-.07	.21***	(.77)			
18	A[8]	22.3	4.3	.04	-.02	-.04	.00	-.09	-.15	-.08	-.06	-.12	-.09	.01	-.09	-.04	.03	-.15	.04	.21***	(.74)		
19	C[9]	21.1	3.9	.21**	.03	-.12	.13*	.11	.09	.12	.13	.09	-.04	.12	-.05	.06	.13	-.27***	.04	.11	.27***	(.72)	
20	Grit	3.4	0.6	.23**	.09	-.02	.20**	.21**	.24**	.22**	.21**	.17*	.09	.22**	.08	.17*	.24*	-.30***	.25**	.24**	.22**	.50***	(.79)

Note: *N* = 272. * $p < .05$, ** $p < .01$, *** $p < .001$. 1 = Overall Climbing Performance aggregate; 2 = Best Three Redpoints, 3 = Highest Three Redpoints; 4 = Highest Redpoint last 12 months; 5 = Neuroticism; 6 = Extraversion; 7 = Openness; 8 = Agreeableness; 9 = Conscientiousness.

Table 2. Grit's incremental validity over Demographics, Five Factor Personality Traits in predicting Outdoor Sport Climbing Performance

		Overall Sport Climbing Performance			Highest Redpoint (Aggregated best three routes)			Highest Redpoint			Highest Redpoint (12 months)			Highest Onsight		
Step	Independent variable	β	Adj. R^2	ΔR^2	β	Adj. R^2	ΔR^2	β	Adj.R^2	ΔR^2	β	Adj. R^2	ΔR^2	β	Adj.R^2	ΔR^2
1	Education (years)	.09	.015		.08	.012		.09	.013		.12	.042		.07	.014	
	BMI	-.09			-.06						-.17*			-.08		
2	Education	.08	.050	.035	.07	.066	.054	-.08	.049	.036	.12	.088	.046	.06	.051	.037
	BMI	-.09			-.06			.08			-.18*			-.07		
	Neuroticism	-.03			-.01			-.08			-.03			.01		
	Extraversion	.05			.06			-.02			.11			.03		
	Openness	.09			.14			.02			.09			.07		
	Agreeableness	-.15*			-.22***			.12			-.11			-.15*		
	Conscientiousness	.14			.14			-.16			.13			.12		
3	Education (years)	.07	.080	.030***	.06	.120	.054***	.07	.078	.029***	.12	.106	.019***	.05	.075	.024*
	BMI	-.11			-.10			-.09			-.19*			-.08		
	Neuroticism	-.01			.03			.01			-.01			.03		
	Extraversion	.01			.01			-.01			.08			.01		
	Openness	.07			.11			.09			.08			.06		
	Agreeableness	-.16*			-.24***			-.17*			-.12			-.16*		
	Conscientiousness	.02			-.03			.05			.05			.04		
	Grit	1.63***			2.25***			1.81***			1.22*			1.25*		

Note: β = *Standardized* β, * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 3. Grit's incremental validity over Demographics, Five Factor Personality Traits in predicting Outdoor Bouldering Performance

Note: *β = Unstandardized B*, * *p* < .05, ** *p* < .01, *** *p* < .001.

		Overall Bouldering Performance			Highest Redpoint (Aggregated best three routes)			Highest Redpoint			Highest Redpoint (12 months)			Highest Flash		
Step	Independent variable	β	Adj. R^2	ΔR^2	β	Adj. R^2	ΔR^2	β	Adj. R^2	ΔR^2	β	Adj. R^2	ΔR^2	β	Adj. R^2	ΔR^2
1	Education (years)	-.02	.003		.07	.013		.08	.003		.08	.013		.05	.009	
	BMI	.16			-.08			-.06			-.07			-.06		
2	Education	-.02	.016	.012	.05	.063	.050	-.04	.014	.011	.05	.063	.050	.04	.057	.049
	BMI	.13			-.09			.13			-.09			-.06		
	Neuroticism	-.11			-.14*			-.10			-.14*			-.12		
	Extraversion	.02			-.08			.03			-.08			-.06		
	Openness	-.05			.12			-.06			.12			.09		
	Agreeableness	-.21			-.09			-.20			-.10			-.06		
	Conscientiousness	-.05			.09			-.08			.09			.09		
3	Education (years)	-.04	.032	.016*	.05	.091	0.28*	-.02	.031	.016***	.05	.091	.028*	.04	.090	.032*
	BMI	.13			-.09			.13			-.09			-.06		
	Neuroticism	-.08			-.12			-.06			-.12			-.11		
	Extraversion	-.04			-.09			-.04			-.09			-.07		
	Openness	-.10			.07			-.12			.07			.06		
	Agreeableness	-.23			-.11			-.22			-.11			-.07		
	Conscientiousness	-.22			.01			-.26			.01			.02		
	Grit	2.61*			1.33*			2.76*			1.33*			1.29*		

INVESTIGATING THE POSSIBLE CONTRIBUTIONS OF CLIMBING IN EDUCATIONAL CONTEXTS

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Abstract
This talk presents an overview of the possibilities for research work on climbing as an educational resource in the new global scenario for climbing that is emerging after the Tokyo 2021 Olympics. With an increasing number of educational spaces promoting this activity, there is an extraordinary opportunity to study the use and contribution of climbing in physical educational programmes. The research carried out so far offers interesting proposals that it would be worthwhile to expand with interdisciplinary research on specific pedagogical aspects, among others, related to the acquisition of skills and capabilities through climbing. This paper offers several insights into current and future challenges and discusses the reasons why climbing can be a valuable educational resource.

Keywords: educational contributions, new climbing scenarios, research possibilities.

INTRODUCTION

Climbing will be an Olympic sport for the first time in Tokyo 2021, opening a new era for the sport and bringing major changes to the climbing world. Among other issues, the focus will be on early training of athletes. National federations have formed their national teams in the different countries and it is likely that in time climbing competitions at school level will be promoted and the activity will reach new levels of dissemination. It would be interesting to analyse how this scenario will change the level of insertion of climbing in physical education programmes in school and other educational contexts and what the implications will be for the development of the theory and practice of its teaching-learning processes.

The fact that it is gaining more and more presence every year as a school physical activity is confirmed by the changes in the official curricula and by the increasing installation of climbing walls in gymnasiums and school facilities (Baena-Extremera, Ayala & Meroño, 2014). Spaces for physical activity are changing and increasingly extending from the original sites of action to places that try to mimic natural conditions (Kulczycki & Hinch, 2014). In this sense, the proliferation of climbing walls has also turned them into places related to education, as they can be found not only in schools, but also in sports centres, universities or sports clubs that promote grassroots

sport (Winter, 2000).

In all these contexts, children and youth are the main actors, and among the ethos of climbing as a modern sport is to promote health and educational values for young people (IFSC, 2020). Thus, the contexts for learning to climb are multiplying. In the new landscape, it is of great interest to understand the activity of climbing in educational contexts, to investigate the wide pedagogical possibilities of this sport and to understand how and to what extent it can function as part of interdisciplinary and holistic educational programmes.

About how climbing could be used in physical activity programs, it is relevant to point that climbing is not generally considered a Fundamental Motor Skill (Newel, 2020), but rather a locomotor movement pattern that allows progression in a more or less vertical medium (Lepage, 1999). Climbing is an activity that has a very particular psychomotricity and requires complex and highly variable motor skills (Perrier, 2004), while FMS would provide the basis for a broader and larger set of unique movement patterns and skills that are usually develop through the sport practice (Newel, 2020). On the other hand, psychomotor qualities such as coordination, balance, agility and fluidity of movement can be developed through climbing (Orth et al., 2015). All these abilities together with postural control and body awareness can be fostered within a climbing activity, which can be interesting content to work with in the context of physical activity/educational programs.

PREVIOUS AND PRESENT RESEARCH ON THE TOPIC

For the first time in the short history of climbing research, there is a pedagogically oriented research trend, which addresses questions such as the effects of climbing on personality development and its possible positive impact (Frontiers, 2020). Research into climbing as an educational resource is undoubtedly a subject that is at the beginning of its academic treatment, and which has enormous opportunities for deepening and creating new lines of research in the future. Through an extensive review of specific literature (Epelde, 2020), it has been found that scientific research on this issue mainly revolves around: climbing as an educational resource, climbing experiences in school settings, social educational interventions through climbing, values education through climbing in outdoor or adventure education, the construction of a climbing wall at school, and skill learning through climbing.

However, while it is clear that there is a consensus among authors about the pedagogical potential of climbing and its possible contribution in educational contexts (Lefort, 1995; Querol & Marco, 1998; Winter, 2000; Pierson-Launay, 2004; Perrier, 2004; Ruiz, 2004; Corcuera, 2006; EDEPS, 2007; Carlux, 2014; Romo, 2015, Navarro & Langa, 2018; Falo, Sanz & Peñarrubia, 2019, among others); it is not easy to find research that provides both qualitative and quantitative results on central questions such as the development and acquisition of competences and skills through climbing. Although many studies propose assessment criteria, observation charts and competence grading systems, they do not provide conclusive data in terms of the learning that students have been able to achieve as a result of the application of their proposals.

On the other hand, different studies suggest that the didactic and pedagogical treatment of climbing can make it participate in education beyond the purely motor aspect (Baena, 2014). The thesis on which this article is based has developed an observation tool to measure a series of skills in the physical and technical dimensions of the exercise of climbing, but also in the cognitive and psycho-affective dimensions (Epelde, 2020). For this research, an observation grid was created out of a deep study of previous literature and other author 's proposals and it was validated by experts in the field.

Specially designed for a long term case study, the grid was used to register competence acquisition in a climbing activity for primary school children. This observation tool provided compelling results reflected in bar graphs suitable for interpretation and offered several key-findings about children's ability acquisition process in the above mentioned learning dimensions; showing children's general evolution from the beginning to the end of the experience, and also the detailed learning over time on each of the observed competences. The outcomes of the recent research could become an interesting basis to continue testing the observation grid in different scenarios and educational contexts and to make improved versions in the future.

ACTUAL AND FUTURE CHALLENGES

In the educational work around climbing, a systematisation that associates the technical and pedagogical aspects inherent to the practice with the results of scientific research in different fields (physiology, neuroscience, biomechanics, etc.) (Vigouroux et al., 2016), would open up new approaches and would help to advance in this still young discipline. In this sense, apart from the study of the acquisition of capabilities that can be developed within a climbing activity in the context of physical education, other subjects of study can be extracted from the experience of the teaching-learning process in a climbing class.

For example, the mentioned thesis (Epelde, 2020) also analyses the influence of the use of space and materials in the learning of climbing, it would be interesting to adapt the knowledge and proposals of the learning environment methodology (Blández, 2016), developing new ideas based on the specificity of climbing. Another interesting proposal would be to design observation tools and models necessary to analyse how motor creativity occurs in climbing, and to study how motor creativity as a method could be applied in a climbing wall (Blázquez, 2016). Finally, the question of verticality, three-dimensional movement and the states of awareness and apprenticeship that favour an intense and joyful relationship with the action of climbing is still underdeveloped (Sicilia, Rojas-Tejada & Moreno, 2008).

Also in recent years, interesting studies have been carried out on the conception, use, management and construction of climbing walls according to their educational use (Baena-Extremera et al., 2014). It would be relevant to analyse the typologies, uses and meanings of these spaces, which currently have areas and activities especially aimed at children. This would allow a better understanding of their educational possibilities, given the variety of proposals and recreational-educational activities that take place in these spaces specially designed for the teaching of climbing.

DISCUSSION

At the heart of the matter is to understand why climbing can be a valuable pedagogical resource. First of all, sport climbing has an educational potential that transcends the purely motor aspect, to work on other levels of education, having particularly great potential in terms of the formation of subjects capable of using their skills positively to solve problems that involve a challenge both on the motor level and on the affective and cognitive levels (Nonini & Saikin, 2011). A climbing activity can contribute directly and clearly to the achievement of the basic competences specified in the official curricula, if it is carried out in conjunction with good pedagogical and guidance work in order to transfer knowledge and positive attitudes through this activity (Briongos & Pérez, 1998; Beas & Blanes, 2010).

Secondly, the sense of ability, mastery or control of one's own body (Goodway, 2008; Goddard, 2011) that can come about through learning to climb, occurs through a series of significant learning experiences around the practice which remain engraved in the child's emotional and bodily memory, and serve as a basis for further attempts and experimentation. Some of these valuable learnings could be identified and observed in our study including: situations of success/empowerment, self-learning or the transfer of climbing movements to a real context. These experiences may also be closely related to the development of Physical Literacy (Whitehead, 2010), to the learning of complex psychomotor qualities and to the acquisition of a specific gestural repertoire. It would therefore be interesting to study the inclusion and contribution of climbing in different physical programs or learning contexts.

And thirdly, a climbing activity that effectively promotes freedom and autonomy of action in a given environment could influence personal development, by expanding and internalising a series resources and skills, which can produce a conscious experience of increasing personal capacities (Goodway, 2008). If in a climbing class, the child is allowed to be the master of his own motor experience, the pupils learn to read the elements of their environment. They can be able to anticipate and respond with intelligence and imagination, identifying in their own movement what is more or less effective and adapting their steps to improve their performance (Franco, 2008). Finally, understanding the inner mechanisms of the above-mentioned aspects around the teaching-learning processes of climbing from interdisciplinary perspectives may lead to interesting approaches in this emerging academic field.

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Day 3 - Session 2

EXAMINING DEI ATTITUDES AMONG U.S. CLIMBERS: ANALYSIS AND FINDINGS FROM A NATIONAL SURVEY

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Abstract

This paper examines the extent to which a concern for matters of diversity, equity, and inclusivity (DEI) is shared by everyday climbers in the U.S. and the factors that shape their DEI attitudes. To do so, we draw data from a national survey conducted in collaboration with the national advocacy organization Access Fund. We conduct a descriptive analysis ranking "lack of inclusivity/diversity" and "climbing on Native or ancestral lands" among 14 concerns facing climbers (such as public lands threats, overcrowding, and climate change). We then apply multiple regression to examine how various climbing and demographic attributes are associated with DEI concerns. Our findings suggest that DEI matters are a relatively low priority and that variation in climbers' DEI attitudes appears driven more by respondents' affiliation with one or more marginalized identities, political leanings, and other sociodemographic characteristics than climbing-related attributes.

Keywords: Rock climbers; diversity; equity; inclusion; Native lands

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A CASE STUDY: PSYCHOLOGICAL INTERVENTION IMPROVES CLIMBING PERFORMANCE

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Abstract

Fear has been considered by the scientific community as an element of psychological stress that impair the performance of climbers. The impairment of performance as consequence of fear seems to be associated to high level of anxiety and low self-confidence. Literature has demonstrated that psychological interventions are as an effective alternative in reducing anxiety in climbing, however there are no evidence about relationship between psychological intervention and performance. The main purpose of the present study was to analyze the effect of a psychological intervention in female climbers with fear on performance. Self-reported anxiety levels and self-confidence was measured by the Spanish version of the Revised Competitive State Anxiety Inventory-2 (CSAI-2R) in seven female climbers before and after a psychological intervention. There was a significant decrease in cognitive and somatic anxiety together with an increase in self-confidence. Female climbers increased their climbing performance significantly after the psychological intervention ($p=0.0015$).

Keywords: fear of falling, anxiety, on-sight, self-confidence, psychological intervention

Introduction

Fear has been considered by the scientific community as an element of psychological stress that impair the performance of climbers (Fryer, 2013; Draper, Jones, Fryer, Hodgson, & Blackwell, 2008; Giles et al., 2014). Previous literature has suggested that on-sight lead climbing was the most demanding and challenging style (Draper et al., 2008). It seems to be due to on-sight lead climbing involves greater fear or anticipation of falling due to lack of previous knowledge of the route characteristics (Aras & Akalan, 2014).

The impairment of performance as consequence of fear seems to be associated to high level of anxiety (Draper et al., 2008) and low self-confidence (Hodgson et al., 2009). Accordingly, Draper et al., (2008) showed that climbers had elevated cortisol concentration associated to cognitive and somatic anxiety in on-sight lead climb condition compared to subsequent lead climb. Moreover, Hodgson et al., (2009) showed that lead climbing resulted more stressful than top rope climbing. These authors observed that climbers showed highest anxiety rating and lowest self-confidence in led climbing condition compared to top rope climbing condition. Furthermore, it seem that this relationship between cortisol and anxiety is only valid in lower level and intermediate climbers and not in more advanced or elite climbers (Fryer, Dickson, Draper, Blackwell, & Hillier, 2013).

Scientific literature demonstrated that psychological interventions were an effective alternative to reduce anxiety in climbing (Maynard, MacDonald, & Warwick-Evans, 1997). However, non-evidence about psychological intervention and its impact on climbing performance has been previously found. The main purpose of the present study was to analyze the effect of a psychological intervention on climbing performance in female climbers.

Methods

Participants

Seven female rock climbers with fear of falling aged between 27 to 37 yrs. voluntary participated in the study. Climbing experience was between 2 and 10 yrs., all of them currently active in rock climbing. On-sight climbing ability ranged from 4+ to 7a. Participants gave their consent and volunteered to participate in this study. The study protocol was performed in accordance with the ethical standards established in the 1961 declaration of Helsinki and was approved by the Research Ethics Committee from University of Cádiz.

Measures

Self-reported climbing ability

In accordance with the Position Statement by the International Rock Climbing Research Association (IRCRA) (Draper et al., 2016), performance grades were converted from French Sport to specific numerical values for all statistical analysis. Climbing ability data were collected before and after Psychological Intervention.

Competitive State Anxiety Inventory-2 (CSAI-2)

Self-reported anxiety levels and self-confidence was measured by the Spanish validated version of the Revised Competitive State Anxiety Inventory-2 (CSAI-2R) (Andrade, Lois, & Arce, 2007). Briefly, the scale consists of 16 items assessing the three hypothesized dimensions of anxiety: somatic anxiety, cognitive anxiety, and self-confidence. The questionnaire had adequate properties, in terms of its dimensionality and internal consistency (Andrade, Lois, & Arce, 2007). SCAI-2R was completed by each participant before and after Psychological Intervention.

Psychological Intervention

Personalized and individualized psychological internet-based intervention was performed in the females' climbers who participated in this study. Psychological intervention was focused on psychoeducation, body interoceptive awareness and cognitive restructuring. The axes of action were physiological, emotional, behavioral, and cognitive. Specifically, we carried out a planning on aspects such as the stressors detection, heart rate regulation and arousal recognition, the identification of emotions, association among emotions and body posture, identification of different forms of emotional expression, identification of avoidance behaviors, identification and modification of maladaptive thoughts, identification of coping skills.

Statistical analysis

All data were found to be normally distributed by Shapiro– Wilk and had equal variances. Post hoc pairwise t-test comparisons were performed before and after psychological intervention SCAI scores and self-reported climbing ability. All analyses were performed using STATA version 14.0 (Stata Corp, College Station, TX, United States).

Results

All data were found to be normally distributed and had equal variances. The personalized and individualized psychological intervention had a duration ranged between 65 to 169 days, with a session number between 3 to 5 and, an hour of duration each one. There were significant differences before and after intervention in all variables measured (See Table 1).

Table 1. Mean (SD) of SCAI-2R measured and self-reported climbing ability before and after psychological intervention.

	Before Intervention	After Intervention	p
Cognitive Anxiety	14.57 (2.22)	8.71 (2.69)	0.002
Somatic Anxiety	16.43 (2.50)	9.71 (1.80)	0.0008
Self-confidence	9.57 (2.37)	14.71 (2.29)	0.0003
Climbing Ability	6a (3.43)	6c (2.42)	0.0015

Discussions

The main finding of the study was a significant average increase of 3 French grade in on-sight climbing level of female climbers after a psychological intervention. The elevated increase in climbing performance was associated to a significant decrease of anxiety (cognitive and somatic) and, a significant increase of self-confidence. In summary, our results suggest that climbing psychological intervention may be an effective treatment to fear of falling and anxiety, producing an improvement in performance. Rock climbers and their coaches should consider psychological training in order to increase or maintain climbing ability.

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UNDERSTANDING KEY PSYCHOLOGICAL CHARACTERISTICS OF ELITE COMPETITION CLIMBERS

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Abstract

Understanding the key psychological characteristics of elite competition climbers has arguably never been more important. As Competition Climbing is now an Olympic sport, national success may depend developing a deeper understanding. Exploring the characteristics of Six (6) elite British climbing athletes, senior and para-climbers (including multiple world champions), guided this qualitative study. Performance Profiling as an implication was reviewed before a focus group interview was performed in which was transcribed and thematically analysed using an inductive and semantic approach. Results consisted of three (3) key themes; (1) Intrinsic Characteristics, (2) Psychological Skills/Performance Strategies and (3) Supportive Environments. Findings uncovered important sub-themes (such as Confidence, Mental Toughness, Conscientiousness, Self-awareness, Team Attachment, Goal-setting, Self-talk, Imagery, Optimised Arousal, Relaxation, Coping, Coach Support, Peer Support and Other Support) in which some or all of the participants had used to garner international success. The details of each theme and their implications and applications are then discussed, with sport specific data possibly required to optimise peak performance in elite Competition Climbing environments.

Conclusions capture how many of these findings support previous literature on elite psychological characteristics when attempting to enhance peak performance.

Day 4 - Session 1

VISUALIZATION OF MEASSURED 3D INTERACTION FORCES DURING OLYMPIC SPEED CLIMBING

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Abstract

Speed Climbing, together with Boulder and Lead will be present at the Tokyo 2020+1 Olympics for the first time. Due to its standardized holds and route, Speed Climbing is well suited for research, long-term performance tracking and comparison between athletes. As part of a larger study, we conducted a feasibility trial with N=5 athletes, all of them competitive climbers, including national team athletes. Based on the standard route, one foot hold and three hand holds were equipped with six degree-of-freedom (DOF) force-torque sensors. These sensors were not visible to the climbers and so stiff, that no perceivable movement occurred. Further, the ground was equipped with a 6-DOF force plate, and a video of the start phase was recorded. Post-trial, we created a 3D force visualization, projected onto the videos. The resulting augmented videos were presented to the athletes and their coaches, allowing them to compare different trials and athletes. We hope that this approach will be of benefit to athletes and coaches. Further, we believe that the visualizations will make the sport of Speed Climbing more approachable and enjoyable to the general public, e.g. when used during television broadcasting.

Keywords: augmented reality, training for climbing, television sport broadcasting, video post processing, climbing video analysis

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BODY AWARENESS AMONG CHILDREN CLIMBERS IN BOULDERING PROBLEM SOLVING

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Abstract

Learning to feel body positioning is essential for a climber and much more for climbers as young children. As far as we know empirically, most adult climbers developed this activity spontaneously and intuitively, in this sense, we find it very important to try to identify and then develop this ability in young children climbers, through bouldering problem solving. The aim of this study was to verify which are the different approaches to body awareness, in solving boulder problems, without pre-visualization of the bouldering routes, performed by children of both sexes. 9 climbers were selected for this study, being (n=2) male and (n=7) female. This assessment consisted of observation of body positioning and gestures as: balance, strength, space, basic balance points, in solving boulder problems. This evaluation consisted of observing if there was innate body awareness on the part of the climbers and agreement between both sexes. There was no statistically significant difference in this bodily awareness in the execution of the routes performed by participants of both sexes. This is a promising tool for identification and pedagogical development for teaching climbing to children, as the format of sport climbing competitions requires also new approaches that is needed to improve their performance.

Keywords: Body awareness; Children climbing; Boulder

EFFECTS OF VARIOUS FORCE INTENSITIE TRAININGS ON FINGER GRIP STRENGTH AND FATIGUE

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Abstract

Climbing-specific training programs on hangboard are often based on dead-hangs repetitions, but little is known about the effect of these trainings when modulating the intensity instead of the time of exercise. The aim of this study is to quantify the effects of different training intensities (maximal and sub-maximal) on the finger physiological capabilities with an instrumented fingerboard. Forty-two skilled climbers were randomly divided among three groups: maximal voluntary contractions (MVC, F100), intermittent repetitions at 80% MVC (F80) and at 60% MVC (F60). All groups trained on a 12 mm hold depth at a rate of two times a week for four weeks. The MVC, the stamina and the endurance level were recorded using an instrumented hangboard before and after training. Results showed a greater maximal grip strength in F100 and F80 groups (+14.3% and +12.4% respectively) but not in F60 group. Significant higher endurance and critical force in F80 and F60 groups were observed but not in F100 group. This suggests that different physiological processes occurred according to the level of training intensities. Interestingly, the different trainings allow improvements in the targeted capacities (e.g. finger strength for the F100) but also in adjacent physiological capabilities (e.g. stamina for the F100).

Keywords: training force intensity, stamina, finger strength

Introduction

The ability to generate finger strength and the ability to limit forearm muscle fatigue are crucial for route success (Watts, Newbury, & Sulentic, 1996). To face the intense and intermittent effort required during climbing, three finger/forearm physiological parameters has been identified in the literature: the level of finger strength which is the capabilities to exert maximal finger force on holds on one or few movements (Quaine, Vigouroux & Martin, 2003; Levernier & Laffaye, 2019). The time to exhaustion (or stamina) which is the capacities to maintain a certain level of high force intensity before exhaustion (Vigouroux et al. 2003; Medernach, Kleinöder & Lötzerich, 2015). The critical force (or long term endurance) which is the level of force intensity that the climber is still able to generate once he is exhausted (Giles, Chidley, Taylor, Torr, Hadley, Randall and Fryer, 2019; Vigouroux & Quaine., 2006). All those three physiological capacities are highly specific due to the specific anatomical and biomechanical configuration of the forearm, hand and fingers such it remains difficult to refer to other sports for designing training programs.

In addition to the climbing practice, it is essential to set up training exercises and programs for involving these physiological parameters (López-Rivera & González-Badillo, 2019). For this purpose, training tools and methods have been developed by climbers and trainers especially based on hanging on holds using hangboards or campusboards. Until now the intensity of the designed exercises can be modulated using three different ways: modulating the size of the hold while hanging with the full body mass, modulating the time of hanging, modulating

the body mass by adding or subtracting lest (Levernier & Laffaye, 2019; López-Rivera & González-Badillo, 2019). When inspiring by other sports, the intensity of force (or load) is always modulated in function of the maximum voluntary contraction (MVC). The main problem is that classical hangboards does not allow to correctly identify the MVC nor to easily modulate percentage of this maximal force. Recent apparition of instrumented hangboards now technically allows such trainings but it is still a lack of knowledge on how the precise loads applied during training generate benefits in the different physiological capacities. This lack of knowledge prevents trainers to select the appropriate training programs corresponding to the physiological objective of the athletes.
The aim of this study is therefore to identify the effects of training intensity levels (low: 60% of MVC; high: 80% MVC; maximum: 100% MVC) on the physiological adaptations in the three physiological capacities (strength, stamina, endurance).

Methods

42 experienced climbers were tested (11 women and 31 men, 23.5 ± 4.5 years old, 173.3 ± 8.6 cm, 63.4 ± 8.0 kg, best red-point grade between 6c and 8c), randomized to three different training protocols (14 climbers in each group). Participants were informed of the risks and signed a consent form. Protocol has been validated by the sport science national ethics committee (CERSTAPS: IRB00012476-2020-19-11-69)
<u>Procedures</u>
Participants perform initial tests consisting of an assessment of maximal finger strength, fatigue stamina and endurance level on an instrumented fingerboard (SmartBoard, Peypin d'Aigues, France). This fingerboard provides a real-time feedback about the vertical force applied on it allowing to precisely modulate the intensity of force (1 N accuracy). Data of force applied to the holds were recorded and analysed using the SmartBoard app (50hz). For the next 4 weeks (weeks 2-5), they follow one of the three training protocol 2 sessions per week. A post-training test, identical to the initial test, was performed at week 6. All tests and trainings were performed on a 12mm edge.
<u>Description of the Test sessions (weeks 1 and 6)</u>
Strength test: After a 30 min warm-up, climbers had to exert the maximum force with one hand on a 12mm hold for 6 seconds (climbers were weighted when needed to perform a force intensity higher to their body weight). Two trials were tested on each hand, and the best was selected. The sum of the maximum forces exerted with the right and left hands was directly displayed on the interface and was considered as the participant's MVC initial (MVCi) and post MVC (MVCp).
*Fatigue test: p*articipants exerted 80% MVCi by alternating a hanging phase of 10s and a rest phase of 6s during 24 repetitions. The 80% level was controlled by the visual force feed-back and adjusted precisely by off-loading with feet on the ground or conversely using additional lest. The fatigue test reproduced the one performed in Vigouroux & Quaine (2006): when the subjects were not able to maintain the required 80% of maximal force, they were required to exert their maximum to reach at best the required level. This were mostly performed by off-loading a part of the body weight with feet on the ground. The recorded fatigue kinetics allows to evaluate the percentage of stamina (determined as the capacity to maintain the required 80% on the overall duration of the test) and the percentage of endurance (determined as the level of force intensity that the climber is able to perform when he is exhausted in comparison to the initial level of force), directly displayed by the app.
<u>Training sessions (weeks 2 to 5)</u>

F60 protocol: participants exerted efforts representing 60% MVC by alternating a 10s hang phase (with or without feet on the ground, weighted if 60% MVC > body weight) and a 6s rest phase, 24 times. Once fatigue occurred, participants must exert their maximum to reach the required level. Two series were performed, spaced out with 6 minutes of recovery.

F80 protocol: participants exerted 80% MVC, alternating a 10s hang phase (with or without feet on the ground, weighted if 80% MVC > body weight) and a 6s rest phase. Once participants were no longer able to exercise 70% MVC, the series stops. Three series were performed, with 8 minutes of recovery time between them.

F100 protocol: this protocol is based on the Levernier & Laffaye (2019) protocol. Climbers applied their maximum force with the right hand, then with the left hand, for 6s each, alternating grip types (slope or half-crimp). Two sets of 6 hangs with each hand are to be performed every 3 min, spaced out with 5 min of recovery.

Statistical analysis

MVC (N), stamina (%), and CF (%) were described using mean ± standard deviation (SD). The effects of training intensity were assessed by comparing the F60, F80 and F100 groups using a two-factor repeated measures ANOVA (Training × Group), with Tukey post-hoc analysis. Significance level was set at $p < 0.05$.

Results & Discussion

Results are summarized in table 1. No Group effect was observed for MVC (F(2,39)=0.806; p=0.45), for stamina (F(2,39)=0.396; p=0.68) and for endurance (F(2,39)=0.535 ;p=0.59) suggesting that the group characteristics were similar at the beginning of the programs. Conversely, a significant Training effect was revealed for the MVC (F(1,39)=81.7 ;p<0.001), the stamina (F(1,39)=43.1 ;p<0.001) and the endurance (F(1,39)=61.2 ;p<0.001) showing that performing the programs improve significantly the physiological parameters. The interaction Training×Group was significant for the MVC (F(2,39)=5.07; p<0.05) and the post-hoc showed that MVC (+14.3±8.8%, +12.4±8.4% and +5.9±8.2% for F100, F80 and F60 respectively) was significantly higher after the training with F80 and F100 groups (p<0.001) but not after the F60 group (p=0.08). The interaction Training×Group was also significant for stamina (F(2,39)=3.94; p<0.05) and for endurance (F(2,39)=4.95; p<0.05). After 4 weeks-training, stamina and endurance was significantly greater in F80 and F60 groups (p<0.001) but not in F100 group (p=0.50 and p=0.33 for stamina and endurance respectively).

	MVC		**Stamina**		**CF**	
	PRE (N)	**POST (N)**	**PRE (%)**	**POST (%)**	**PRE (%)**	**POST (%)**
F60	869.3 ± 220.7	912.1 ± 200.8	32.6 ± 15.3	53.5 ± 25.1*	65.7 ± 11.0	78.5 ± 9.6*
F80	767.0 ± 185.7	852.1 ± 178.5*	29.5 ± 21.3	60.4 ± 25.7*	63.2 ± 11.3	79.2 ± 11.5*
F100	809.6 ± 124.6	920.4 ± 115.9*	33.5 ± 23.5	43.1 ± 24.0	65.3 ± 14.8	70.4 ± 15.0

*Table 1. Mean ± SD values of MVC (N), stamina (%) and CF (critical force in %) in each group, pre- and post-training. * indicates significant difference from pre-training (p < 0.05)*

The enhancement of MVC with the F100 could be due to neural adaptations during the first weeks (López-Rivera & González-Badillo, 2012) which allows a better recruitment of motor units in a very short time and a better anaerobic capacity in forearms, in order to generate a major muscular activation. With F80, which represents intermittent submaximal exercise with high intensity, the improvements could be explained by the fact that this type of exercise causes local ischemia in forearms through decreased blood flow and lactate accumulation (Ferguson & Brown, 1997; Philippe, Wegst, Müller, Raschner & Burtscher, 2012). This may generate a "natural" blood flow restriction, which would promote strength gain as it is observed for other Musculo-skeletal system (Abe, Beekley, Hinata, Koizumi & Sato, 2005). On the contrary with F60, the intermittent exercise does not seem to have sufficient force intensity to generate large MVC improvements.

Given that F80 and F100 groups increased their MVC, the load applied to perform the fatigue post-test (80% of MVCi) becomes less than 80% of their new MVCp. Thus, fewer motor units need to be activated for the same load and there is a potential to recruit a greater number of non-fatigued motor units. This then delays the intervention of type II fibers and the accumulation of lactic acid, allowing a longer time to exhaustion. Higher stamina is thus observed for the F100 and F80. Nevertheless, the improvement of stamina level for the F80 was steep higher. This maybe explain by the nature of the training which probably generates improved aerobic capacity by a better the storage capacity of glycogen and phosphagen, the greater supply, irrigation and consumption of oxygen in the muscle are better, increasing the oxidative capacities of the skeletal muscle (Ferguson & Brown, 1997; Fryer et al., 2016).

Trainings with intermittent exercises (F60 and F80) generate greater accumulation of fatigue than the maximum intensity training (F100). Even if the force intensities were lower during those trainings (F60 and F80), they allowed a better tolerance to fatigue in comparison to F100. This explain the better improvement of the endurance level for F60 and F800. This probably due to the development of aerobic capacity through faster reoxygenation of the forearms (better vasodilatation) during rest phases (Ferguson & Brown, 1997) as well as better elimination of muscular waste products (lactic acid).

Results showed that a 4 weeks-training program on instrumented hangboard was sufficient to improve physiological parameters with all different force intensities. The different force intensities generate different adaptations but the F80 appeared as very interesting as it allows a simultaneous improvement of each physiological parameters.

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ATHLETES PERFORMANCE IN DIFFERENT BOULDER TYPES AT INTERNATIONAL BOULDERING COMPETITIONS

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Abstract

The aim was to analyse the frequency of different boulder types and the athletes' success rates in international bouldering competitions. Therefore, we classified 448 boulder sections of the semifinal and final rounds of 14 Bouldering World Cups 2017 and 2018 by video analysis. We conducted analysis of frequencies, chi-square tests, binomial regressions and ANOVA for the respective analysis with regard to gender, competition round, wall section, and athlete's level. Frequency distribution of boulder types was not equal between the single competitions, however, dynamic moves occurred the most frequent. Furthermore, the athletes success rates were different between the boulder types with dynamic moves being completed less often than boulders of the other types. When comparing more successful with less successful athletes, we found differences between genders: In the women´s category, the more successful athletes outperformed the other ones in all type of boulders whereas in the men´s category in as dynamic moves and slap categorised type of boulders. Our findings suggest that the training focus for worldcup athletes should be on optimising dynamic moves. For female athletes, maximum strength of fingers and arms is more important in competitive bouldering than for males.

Keywords: climbing; competition analysis; competitive climbing

Introduction

Competition modelling aims to evaluate the competition conditions in order to be able to specify training goals (Hohmann, Lames, Letzelter, & Pfeiffer, 2020). In bouldering competitions, the route setters determine to a large extent the demands on the competition climbers by setting the boulder problems in the various rounds of the competition. For specific competition preparation, a task-specific analysis of international bouldering competitions is required to determine the frequency of occurrence of different boulder types. This included looking for noticeable abnormalities in different rounds of competitions as well as in different wall sections. In addition, it was aimed to find out whether the athletes completed the different boulder types with different degrees of success and how top athletes differed from less successful ones.

Methods

For data acquisition, videos of all seven Bouldering World Cups 2017 and all seven Bouldering World Cups 2018 were analysed. Video recordings were optained from the freely accesible IFSC youtube channel. For every competition, we analysed all four boulder problems of the semi-final and final round for women and men. Boulders are subdivided into two scoring sections, up to the zone hold and on to the top. Thus, the data basis for our analysis was 224 boulder sections for the women and 224 boulder sections for the men, i.e. a total of 448 rated boulder sections.

In order to determine the type of the boulder section, we identified the main challenge, the so-called crux of the respective section. Therefore, we observed each athlete in the section and took the point where most athletes fell off as the crux. From the multitude of possible boulder problems described by Köstermeyer (2018) we aggregated five different types: 1) Dynamo: dynamic moves to reach the holds. This type includes all moves that either involve jumping off, reaching with both hands or with a hand and a foot simultaneously, or several dynamic moves directly following each other. 2) Volume: strength requirements on voluminous holds. These include slopers and volumes as well as all other large holds that are grasped with the whole hand, with a pincer grip or meat-hook grip. In the meat-hook grip, the hand is wrapped over an edge with the palm on one side and the fingers on the other. 3) Crimp: strength requirements on crimps. With this type we classified boulder sections in which small holds are held with an open or crimped finger position. 4) Slab: balance requirements on slightly forward inclined walls with mostly small holds for hands and feet. 5) Mantle: strength requirements for mantling or stemming with the arms, for example to overcome small terraces or, more common in competitive climbing, to overcome large volumes. To test inter-rater reliability, two independent raters categorised 53 randomly selected boulder sections (12%). Kappa statistics showed a substantial agreement according to Landis and Koch (1977), *Cohen's kappa* = .679, $df = 52$, $p < .001$.

Climbers performance was scored according to the IFSC rules and the IFSC world ranking accessed at the respective time of the competition. To test for performance differences, we divided the sample into the top 20 level athletes of the world ranking (69.9%) and lower or unranked athletes (30.1%).

All the statistical analyses were performed using SPSS software (IBM SPSS, Version 26.0) We conducted analysis of frequencies, chi-square tests, binomial regressions and ANOVA for the respective analysis with regard to gender, competition round, wall section, and athlete's level.

Results

Figure 1 shows the prevalence of the different boulder types for women and men in the respective round.

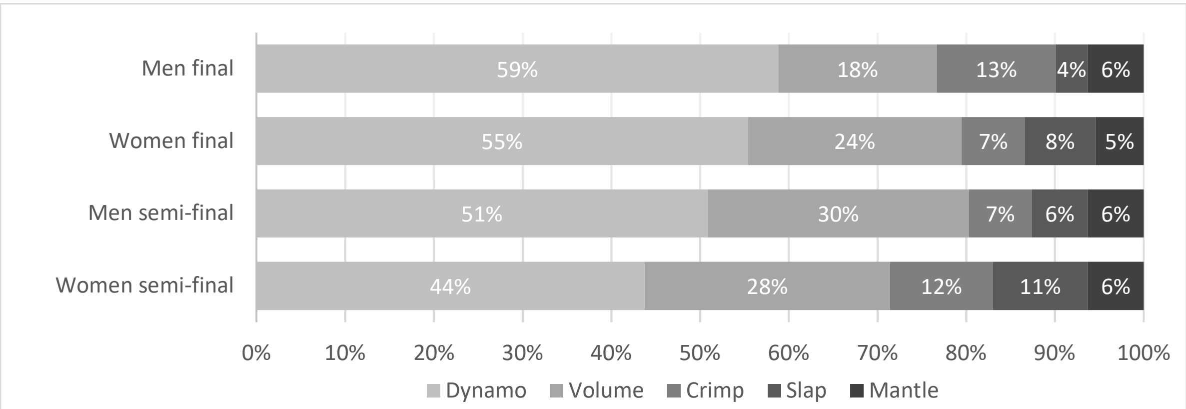

Figure 4: Prevalence of boulder types

Boulder types did not occur with equal frequency in the Bouldering World Cups, $\chi^2(4) = 341.799$, $p < .001$. The share of dynamic requirements was by far the largest. Between the boulder types, the athletes' success rates were different, $\chi^2(4) = 31.222$, $p < .001$, $\varphi = .078$ with dynamos beeing completed significantly less often than some of the other types.

Looking at the proportion of each boulder type in the sections up to the zone hold and up to the top, there were differences in the frequencies, $\chi^2(4) = 14.308$, $p = .006$, $\varphi = .179$. In 40.2% of the boulders the cruxes were the same up to the zone and up to the top, in 59.8% they were different.

In none of the boulder types there was a different distribution between the semi-final round and the final round, $\chi^2(4) = 5.925$, $p = .205$, $\varphi = .115$ (s. Table 1). For men and women, essentially the same number of boulder problems were set in the respective types.

The comparison between the top-20 and the 21+ ranked showed different results between the genders. For women, the top-20 women outperformed the 21+ ranked in all types, For the types dynamo, $\chi^2(1) = 56.211$, $p < .001$, $\varphi = .219$, volume, $\chi^2(1) = 32.137$, $p < .001$, $\varphi = .214$, and crimp, $\chi^2(1) = 19.386$, $p < .001$, $\varphi = .273$ the differences were significant, for the types mantle, $\chi^2(1) = 2.754$, $p = .097$, $\varphi = .148$, and slab, $\chi^2(1) = 3.118$, $p = .077$, $\varphi = .109$, we found a tendency. However, men showed a different pattern. In the types dynamo, $\chi^2(1) = 45.923$, $p < .001$, $\varphi = .186$, and slab, $\chi^2(1) = 9.741$, $p = .002$, $\varphi = .246$, the top-20 outperformed lower-ranked athletes. However, in the types crimp, $\chi^2(1) = .032$, $p = .857$, $\varphi = .012$, volume, $\chi^2(1) = .478$, $p = .489$, $\varphi = .026$, and mantle, $\chi^2(1) = 2.474$, $p = .116$, $\varphi = .121$, the 21+ ranked athletes were not noticeably worse than the top-20.

Discussion

The results of this study can be used to draw practical conclusions for training in competitive climbing.

The first indication lies in the finding that in about half of the boulder sections the crux was a dynamic move. Since we also found that athletes struggled with dynamos more often than with other problems and needed more attempts which has a high impact in the ranking as well, it seems to be very worthwhile to set a training focus on dynamic movements. Due to the nature of dynamos precision and timing are needed to hit the holds and stick to them. This supports the requirement for a lot of practice of a wide variety of dynamic movements to improve accuracy.

A second important aspect is that in almost 60% of the boulders the demands up to the zone are different from those up to the top. In the immediate preparation for the next boulder in the isolation, the athlete should adjust the activation level to the demands of the boulder. Also during climbing, the change between different demands is not only physically but also mentally challenging. This adjustment to different demands in terms of activation levels should therefore also be considered in training.

A third indication can be derived from the comparison between the top 20 level and lower ranked athletes. This showed that the performance deficit among women compared to the top athletes is significantly greater than among men. Especially in the strength requirements, the 21+ ranked female athletes were particularly behind. With men, by contrast, it looks different. Although the male top-20 athletes outperformed lower-ranked athletes in the types dynamo and slab, there were no significant differences in the types volume and mantle. In crimp problems they were even almost equal. Thus, in men, the maximum strength does not seem to differentiate the absolute world elite in competitive bouldering from the somewhat less successful athletes. This is consistent with the findings of Cutis and Bollen (1993) who showed that there was no evidence that hand strength alone guaranteed success in competitive climbing. While this study dates back some time, Augste and Künzell (2017) also support this finding. They showed through guided interviews with national coaches that high maximum arm strength is more likely to be seen as a ticket to competitive climbing than a performance differentiating factor. This is also supported by the study of Michailov et al. (2009) who found that the group of the competition boulderers was relatively homogeneous according to the specific strength. While in their study, as in ours, maximum strength was not decisive for success for men in the bouldering world cup, in our study accurate dynamic moves were crucial. As a consequence, coordinative aspects and quick power development should be focused on in training as a basis for successful dynamos in men whereas women should focus on strength training.

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Day 4 - Session 2

EXPLORING NEW HEIGHTS: VISUAL BEHAVIOUR OF NOVICE, INTERMEDIATE, AND EXPERIENCED CLIMBERS

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Abstract
The aim of the current study was to explore the gaze behaviour of novice, intermediate, and experienced climbers when climbing an indoor top-rope route. Twelve novice, twelve intermediate, and ten experienced climbers tried to reach the top of a climbing route with progressively increasing difficulty. Based on climbing performances, an easy, intermediate, and difficult section was determined on the route. Gaze behaviour was analysed by categorising all fixations as either ‘movement related’ or ‘exploratory’, and either directed to handholds or footholds. Gaze behaviour was compared between the three groups on the easy section, and the effect of route difficulty on the gaze behaviour of the experienced group was studied. Regardless of experience, fixations related to a reaching or grasping were of longer duration than exploratory fixations. On average, experienced climbers used longer fixations than novices, but this was only the case for movement related fixations. Visual attention to foot placement increased with experience, and decreased with increasing task difficulty. Being able to pay sufficient visual attention to foot placement may therefore be a contributing factor in successfully climbing a route.

Keywords: Expertise, Gaze behaviour, Motor control, Perception-action,

Introduction

To efficiently plan and guide our movements, we primarily rely on visual information. Eye tracking has therefore been used for decades as a tool to study how visual information contributes to motor control (Mourant & Rockwell, 1970; Land, 2006). In sport climbing, visual information plays a crucial role in planning the route during the previewing phase, and in guiding the movements during the ascending phase. Eye tracking studies have revealed that experienced climbers preview a route by gradually inspecting blocks of 2 to 4 grips, a visual strategy which is referred to as ‘sequence of blocks’ (Grushko & Leonov, 2014). However, how visual information is used during the climbing phase, and how this changes with experience, has hardly been studied.

Based on a study of Nieuwenhuys et al. (2008), who tested the influence of anxiety on visual attention during climbing, it seems that fixations coupled to reaching/grasping have a longer duration (603 ± 194ms) than exploratory fixations (243 ± 43ms). Furthermore, they reported that their participants (novice climbers) spent most of their time looking at handholds (compared to their hands, the wall, or other regions), and that in a higher state of anxiety, participants made longer fixations, spent more time looking at task-relevant locations, and had a decreased search rate. This suggests that with increased anxiety, the processing efficiency of the novice climbers decreased. In line with this, Knobelsdorff et al. (2020) and Hacques et al. (2021) showed that gaze behaviour while climbing is related to climbing expertise and experience. It is still unclear however to what extent the findings of Nieuwenhuys et al. (2008), that exploratory fixations are shorter than fixations during reaching/grasping, and that climbers spend most time looking at handholds, can be transferred to experienced climbers.

The aim of the current study was to explore the gaze behaviour of novice, intermediate, and experienced climbers. It is expected that 1) fixations related to an action will have longer duration than those related to exploration, 2) experienced climbers use fewer but longer fixations, and 3) increasing task difficulty will affect fixation location and duration.

Methods

After a warm-up routine and a one-minute preview of the route, twelve novice (little to no climbing experience), twelve intermediate (± level 5c on French scale), and ten experienced climbers (±7a) tried to top a 16m top-rope climbing route with 39 grips, and with progressively increasing difficulty, starting at 4a and ending at 7c. Gaze behaviour was recorded using the SMI Eye Tracking Glasses (ETGw2 wireless, Teltow, DE), which was calibrated at 1 meter distance from the wall, using 3 grips. A calibration check was performed at the end of the experiment.

Using the semantic gaze mapping function of BeGaze (SMI), all fixations, automatically detected by the SMI fixation detection algorithm, were categorised as movement related (fixation carried out while reaching/grasping for a grip) or explorative (looking at grips without making a movement towards it); and as hands, or feet (depending of the grip being used for a hand grip or for a foot support). Additionally, when a fixation was detected but fell outside the gaze overlay video (e.g. by looking over the frame of the eye tracking glasses) the fixation was marked as gaze out of screen. Other fixations were labelled as 'other'.

The route was subdivided in three sections based on where most novices and intermediates fell from the wall. Section A (grip 1-15) was cleared by all participants, section B (grip 16-21) by most intermediates and all experts (no novices), and section C (grip 22-39) by some experts (no novices or intermediates). *Performance* was rated as the highest grip which was reached. *Climbing speed* was calculated by dividing the number of the highest grip the participant touched (-4 as participants started with their hands at grip nr. 4) by trial duration. After categorising all fixations, *average fixation duration* (FixDur), and *dwell time percentage* (Dwell%; total fixation duration to one AOI divided by the total fixation duration to all AOIs) were calculated per participant and per section of the climbing route. Repeated Measures MANOVAs were applied to test the effect of experience on section A, and the effect of route difficulty on the experienced group

Results & Discussion

Performance increased significantly with increasing climbing experience (Novices: 15.58 ± 1.38), Intermediates (22.58 ± 5.89), Experienced (36.00 ± 3.50; $F_{2,31} = 70.077$; $p < 0,001$; $\eta p2 = 0.819$), and also climbing speed on section A increased with increasing experience (Novices: 0.37 ± 0.16 grips/sec; Intermediates: 0.49 ± 0.18 grips/sec; Experienced: 0.74 ± 0.21 grips/sec; $F_{2,31} = 12.701$; $p < 0.001$; $\eta p2 = 0.450$). Tracking Ratio of the gaze data was significantly lower in the Novice group (38.53 ± 11.31%) compared to the Intermediate (58.91 ± 8.05%) and Experienced group (51.24 ± 9.24%; $F_{2,31} = 13.607$; $p < 0.001$; $\eta p2 = 0.467$).

Analysis of gaze behaviour on section A (the easiest part) showed that for all participants fixations related to a movement were of longer duration than exploratory fixations ($F_{3,93} = 41.943$; $p < 0.001$; $\eta p^2 = 0.575$), which is in line with findings of Nieuwenhuys et al., 2008. On average, experienced climbers used longer fixations than novices ($F_{2,31} = 9.094$; $p = 0.001$; $\eta p^2 = 0.370$), but this was only the case for movement related fixations, not for 3

exploratory fixations (see Figure 1). Novices spent significantly less time making movement related fixations to the feet than intermediate and experienced participants ($F_{2,31} = 16.424$; $p < 0.001$; $\eta p^2 = 0.514$; See Figure 2, left).

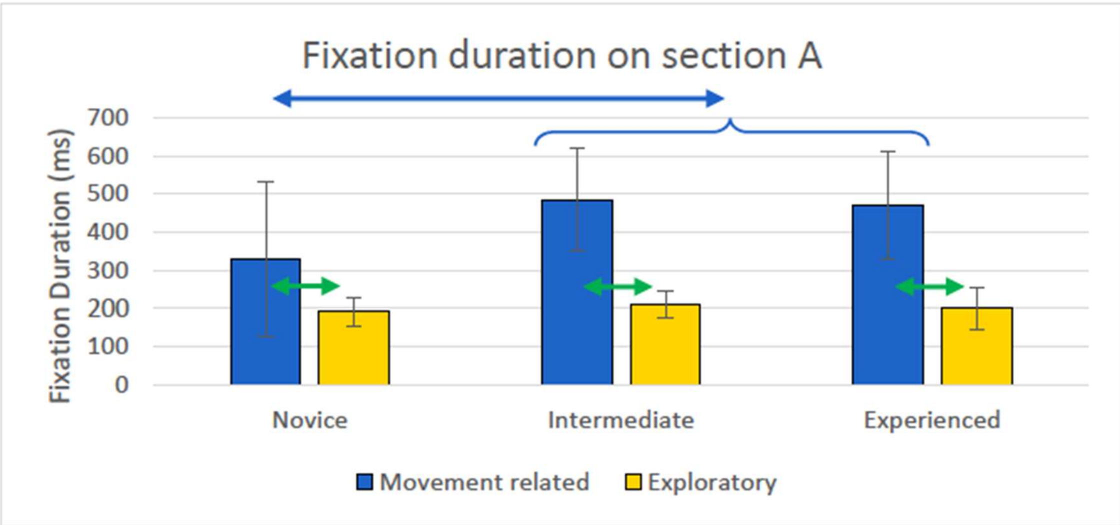

Figure 2. Duration of movement related and exploratory fixations on section A, per group. Significant differences indicated with arrows.

Comparison of results on the three sections for the experienced group (effect of task demand) showed that climbing speed decreased with increasing difficulty (A: 0.74 ± 0.21 grips/sec; B: 0.34 ± 0.10 grips/sec; C: 0.17 ± 0.05 grips/sec; $F_{2,18} = 63.993$; $p < 0.001$; $\eta p^2 = 0.877$). On the more difficult section of the route, gaze was used more often to look for hand grips ($F_{2,8} = 5.840$; $p = 0.027$; $\eta p^2 = 0.593$), and less often in function of hand ($F_{2,18} = 5.521$; $p = 0.013$; $\eta p^2 = 0.380$) or foot movements ($F_{2,18} = 13.226$; $p < 0.001$; $\eta p^2 = 0.595$; see Figure 2, right). No effect of task difficulty on fixation duration was found ($F_{4,34} = 1.373$; $p = 0.264$; $\eta p^2 = 0.139$).

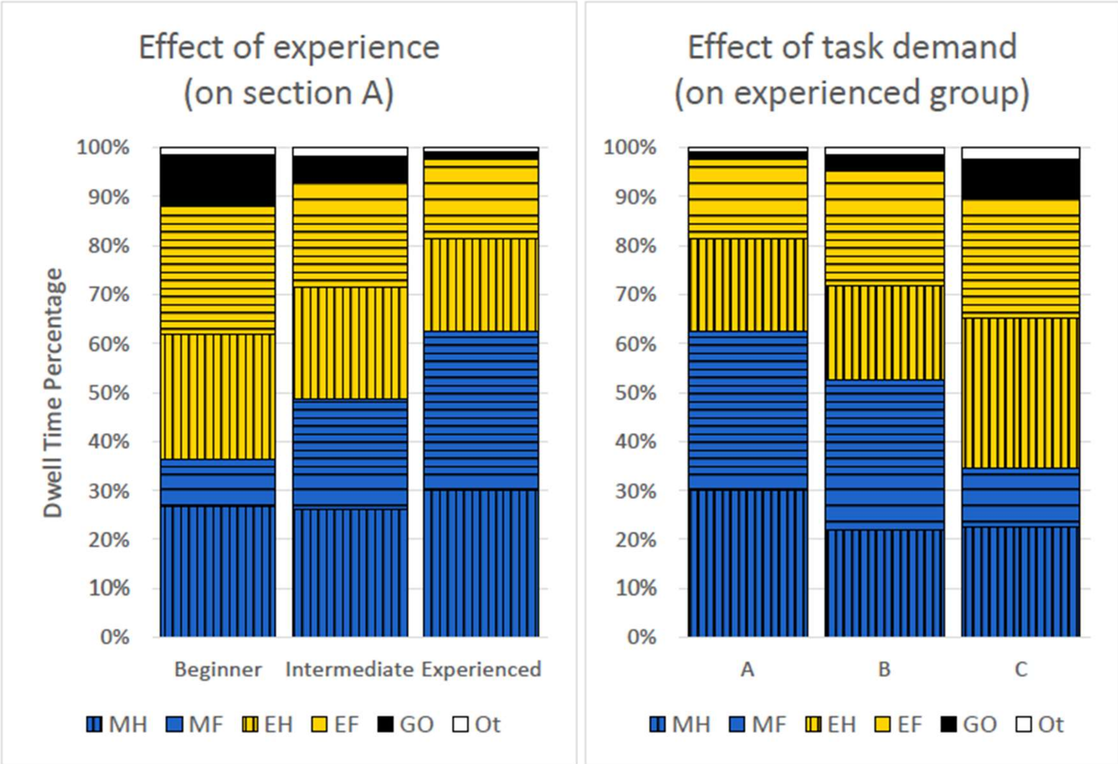

Figure 2.The effect of experience (group) on dwell% in section A (Left), and the effect of task demand (section) on the dwell% of the experienced group (Right). MH = Movement Hands, MF = Movement Feet, EH = Explorative Hands, EF = Explorative Feet, GO = Gaze Out of screen, Ot = Other

Compared to novices, experienced climbers use longer fixations when grasping or reaching for the next grip. It is not clear however if this is the result of information processing, movement planning, or another underlying mechanism. In contrast to what was expected, no differences in fixation duration were found between the intermediate and the experienced group, and no effect of task difficulty on fixation duration was found. This suggests that attentional control and movement planning are important skills for climbing, but are not discriminating skills between intermediate and experienced climbers. Other factors such as grip strength (knobelsdorff et al., 2020) and endurance, postural strategies, force distribution across the holds, and psychological characteristics are most likely more determining for success in climbing than the perceptual-motor skills studied in the current experiment (see Saul et al. 2019 for a review on determinants for success in climbing). Visual attention to foot placement increased with experience, and decreased with increasing task difficulty. Being able to pay sufficient visual attention to foot placement may therefore be a contributing factor in successfully climbing a route.

Regardless of experience, fixations related to a reaching or grasping were of longer duration than fixations made while in stationary position. This shows that not only the timing and location of fixations is coupled with the perceptual-cognitive requirements of the ongoing action, but also the fixation duration. In sports, fixations should therefore be studied more in accordance with the purpose of the visual information that is being acquired, rather than only taking into account the location of the fixation and/or the level of expertise of the athlete.

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CLIMBER-BELAYER RELATIONSHIP IN HIGH SCHOOL STUDENTS: ON WHICH CRITERIA THEY BASE THEIR PARTNER CHOICE

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Abstract

In a high school climbing association, students from all levels practice sport climbing on an artificial wall of 16 meters height. The group of 45 climbers, aged between 11 and 16, with different amounts of experience, show an interesting phenomena when it is about to choose their climbing partner. The dynamics inside of the group were regarded from a social psychology point of view. The aim of this study is to examine if climbers in this same group choose their belayers based on objective or rather subjective criteria. In order to answer this question two different questionnaires based on the sociometric test were distributed in a time span of four months. Of which the first one serves to assess the empathy relations that exist in the group. The second one aims to understand if they consider sport climbing as a risk activity and for which reasons. Finally they were asked which partners they will choose in different activities, among those climbing. The results show that youngsters consider sport climbing as a low risk activity and that they choose their belayers from the circle of their friends, justifying their choices by subjective criteria of empathy.

Keywords: sociometric test; risk; indoor climbing; schoo

WORKING MEMORY FUNCTIONING IN OUTDOOR CLIMBERS

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Abstract

Purpose: To investigate the relationship between domain-general Working Memory (WM) functioning and self-reported on-sight climbing ability in a group of experienced climbers.

Methods: Cerebral perfusion in the frontopolar region (O_2Hb and HHb) while performed WM from a Corsi Tapping task, were assessed in twenty-two male climbers.

Results: Linear regression analysis revealed that WM capacity and mistakes was negative associated with the highest climbing ability ($P<0.001$). Further, adjustment for covariables (age, educational level, fat mass and O_2Hb and HHb prefrontal cortex) did not affect the model.

Conclusion: Our results suggest that general-domain WM measured objectively is negatively associated with climbing ability after controlling for potential confounding factors. Rock climbers and coachers should endorse how climbers use their WM in their climbing training program to increase or maintain climbing performance.

Keywords: IRCRA2020; Rock climbing; Tokyo, working memory, prefrontal cortex

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ANXIETY LEVEL AND SENSE OF COHERENCE DURING 10 WEEK CLIMBING TRAINING PROGRAM

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Abstract

Relationship between anxiety level and sense of coherence was studied in a group of beginner climbers. Authors have created a 10 week training program which assumed using mental training skills such as: breathing control, attention concentration, memory training and relaxation. The experimental group was consisted of 40 physical education students aged 22-25. The control group was consisted of 40 other students who worked the same climbing training program excluding the mental training parts. The anxiety level was measured using the *State-Trait Anxiety* Inventory (STAI). Sense of coherence was measured using Antonovsky's Sense of Coherence Scale (SOC-29). The tests were carried out at weeks 1 and 10. Results show that in both groups the level of state anxiety was decreased by M=2,86 points in the experimental group and M=1,89 points in the control group. Results show that the level of state anxiety reduction depends on the level of sense of coherence subscales: intelligibility, resourcefulness and meaningfulness.

Keywords: Anxiety, Sense of coherence, Climbing, Mental training.

Acknowledgements: we thank the Eiger Climbing Center in Wroclaw, Poland for cooperation during the research.

VIDEO PRESENTATIONS

PREVALENCE OF AMENORRHEA IN ELITE FEMALE CLIMBERS

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Abstract:

Elite sport climbers exhibit a high strength-to-weight ratio and are reported in the literature to be lighter and leaner than their athletic counterparts. Current research regarding nutrition among climbers is sparse but suggests that they may be at high risk for low energy availability (LEA) and Relative Energy Deficiency in Sport (RED-S). Prevalence of amenorrhea, one of the first indicators of RED-S, is unknown in this athletic population. The purpose of this study is to determine the prevalence of current amenorrhea (menstrual disturbances within the previous 12 months) among elite level female competitive sport climbers. We administered a survey to female climbers registered as competitors within the International Federation of Sport Climbing (IFSC) to assess prevalence of amenorrhea and examine relationships among amenorrhea and diet history, disordered eating, weight, training load, competition status, etc. Results are still being collected and the data are not yet available.

Keywords: Low energy availability; Rock climbing; Competitive climbing; Menstrual disturbance; Female athletes

Introduction:

Research has demonstrated that female athletes display higher prevalence of menstrual disturbances than their non-athletic counterparts (Beals & Hill, 2006, De Souza & Williams, 2004, De Souza et al., 2010). Athletes participating in lean-build sports are at increased risk for menstrual disturbances due to the emphasis on maintaining a low-body weight (Torstveit & Sundgot-Borgen, 2005, Nichols, Rauh, Barrack, Barkai, & Pernick, 2007, Warren & Chua, 2008). This emphasis on low-body weight leads to a state of low energy availability (LEA), a condition in which energy intake is inadequate to compensate for energy expenditure (Mountjoy et al., 2018).

LEA is commonly linked to the development of Relative Energy Deficiency in Sport (RED-S) which is a state of compromised physiological functioning that includes, but is not limited to, impairments of metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health (Mountjoy et al., 2018). Suppression of reproductive function during conditions of chronic energy deficiency is well recognized as an energy conserving response to preserve fuel for more vital bodily processes such as cellular maintenance and locomotion, and to avoid the energy costly functions of gestation and lactation (De Souza & Williams, 2004, Mountjoy et al., 2018, Nattiv et al., 2007, Wade et al., 1996).

Climbing is categorized as both a lean/aesthetic sport and as a gravitational sport. Athletes in these sports display an increased prevalence of disordered eating and chronically low body-weight (Sundgot-Borgen & Garthe, 2011). Research indicates that elite climbers are generally shorter, leaner, and lighter than non-climbing athletes and they exhibit anthropometric profiles similar to gymnasts, ballet dancers, and long distance runners (Giles, Rhodes, & Taunton, 2006, Sheel, 2004, Watts, Joubert, Lish, Mast, & Wilkins, 2003). Previous studies examining nutritional intake among climbers indicate a high prevalence of disordered eating among elite female climbers (Joubert, Gonzalez, & Larson, 2020). Additionally, anecdotal evidence points to a culture that values thinness and often encourages athletes to minimize weight through restrictive eating habits. This drive for a high strength-to-weight ratio can cause athletes to maintain a state of chronic LEA, which can subsequently lead to menstrual disturbance. The prevalence of amenorrhea in climbers is currently unknown. The aim of this study is to determine the number of athletes with amenorrhea among elite female competitive sport climbers and uncover correlations among other factors, such as diet history, disordered eating, weight, training load, and competition status.

Methods:

We administered an online survey (Qualtrics XM, 2021) to female competitors registered with the International Federation of Sport Climbing (IFSC). The survey was approved by the ethics committee at Northern Michigan University. The survey link was distributed via IFSC to the email addresses of the participants. Participation was optional, participants could choose to not participate at any point while taking the survey, and identities were not collected. The survey consisted of sections, including: 1. Informed consent, 2. Demographics, 3. Climbing experience, training volume, climbing discipline, and injury history, 4. Menstrual history and contraceptive use, 5. Weight, diet, and disordered eating history. Results will be analyzed using SPSS software.

Results & Discussion:

Results are still pending. We anticipate the data analysis to be conducted in August 2021.

Glossary:

- Amenorrhea
    - Primary – delayed menarche or absence of menstruation by age 16 (De Souza & Williams, 2004)
    - Secondary – absence of menses for three or more consecutive months after menarche
- Oligomenorrhea – irregular and inconsistent menstrual cycles lasting from 36-90 days in length or fewer than 10 menstrual cycles in the past year (De Souza & Williams, 2004).
- Eumenorrhea – 10 or more menstrual cycles of 25-38 days in the past year

- Menarche - occurrence of the first menstrual cycle
- Low Energy Availability (LEA) - a mismatch between an athlete's energy intake (diet) and the energy expended in exercise which leaves inadequate energy to support the functions required by the body to maintain optimal health and performance (Mountjoy et al., 2018).
- Relative Energy Deficiency in Sport (RED-S) - impaired physiological functioning caused by low energy availability which includes, but is not limited to, impairments of metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health (Mountjoy et al., 2018).

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SUGGESTIONS FOR TREATMENT OF FINGER SKIN INJURIES IN SPORT CLIMBING COMPETITIONS

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Abstract

In sport climbing, wounds, calluses and athlete's foot are common. These troubles affect the performance of climbers and require appropriate measures. In particular, the treatment of wounds in competitions is a typical issue, because the treatment for bleeding is regulated in the rule book. Poor treatment by medical staff will interfere the subsequent climbing of the athlete and the operation of the competition. In our experience, treatment for fingers in a limited time is a nervous issue for both athletes and medical staff. Therefore, we examined the optimal treatment for finger wounds. Typical climbing-related finger bleeding occur on distal groove, lateral nail fold, proximal nail fold, fingertips, wrinkle of joint and knuckles. The most important thing to consider is to cover the fingertips wound with a material that has friction, which cannot be easily removed. For knuckle wounds, it is also important to take care to minimize the flexion by the dressing such as tape. Specifically indicate the method for treatment, it is possible to eliminate the difference between the staff skills by training in advance. We hope that many medical staff will refer to our method for the athletes and smooth competition management.

Keywords: finger wound, bleeding, medical staff

Introduction

Because the skin is an organ on the surface of the body, athletes face various skin troubles in the sport scene. Wounds such as abrasions and lacerations are common traumas in many sports. It has been reported that wounds account for a high proportion of trauma in various sporting events [1,2]. These wounds are mainly due to falls, contact between players, and irritation from tools and instruments. In addition to wounds, nail trauma, skin infections, and skin problems caused by ultraviolet rays are also important issues in sports dermatology. Based on these, we would like to emphasize that dermatologists are an important position in sports medicine.

In sport climbing, wounds, calluses and athlete's foot are common [2,3]. Wounds are most common on exposed areas of the limbs, which are injured by contact with the wall or holds [2]. These are most often accompanied by bleeding. Calluses are frequent findings in the hands of climbers and are formed by holding repeatedly [3]. The presence of calluses causes discomfort such as pain. Athlete's foot is a fungal infection, also called tinea pedis. It may be asymptomatic but may suffer from severe itching. When the lesion extends to the nail, the nail becomes thicker and the pressure in the shoe causes pain. Bleeding and discomfort such as pain and itching affect the climber's performance and should be treated appropriately. Dermatologists can address these issues.

In competitions climbers suffer various injuries, the most common of which are bleeding wounds [2]. At that time, medical staff must treat them, because the treatment for bleeding is regulated in the rule book. The rule book created by the International Federation of Sport Climbing says "the competitor shall be able to stop the bleeding so as to be sure that he will not put blood on the holds". Treatment of limb wounds is not difficult, but finger wounds is tricky. The most important thing to keep in mind is that the dressing for stopping the bleeding and covering the finger wound sometimes leads to difficulty for the athlete to climb. Another issue is that the time available for treatment is a few minutes in boulder competitions. We always feel that treatment for fingers in a limited time is a nervous issue for both athletes and medical staff. Therefore, we examined the optimal treatment for finger wounds.

Frequent finger wounds

We are supposed to deal with the injuries and illnesses of athletes as medical staff at the competitions sponsored by Japan Mountaineering and Sport Climbing Association (JMSCA). Our experience has shown that typical climbing-related finger bleeding occur on distal groove, lateral nail fold, proximal nail fold, fingertips, wrinkle of joint and knuckles (Figure 1). Distal groove wounds are caused by the tip of the nail peeling off (Figure 1a). Lateral nail fold wounds develop with invagination of the nail (Figure 1b). Proximal nail fold wounds are triggered by hangnail and dryness (Figure 1c). Fingertips wounds bleed as the skin becomes thinner with repeated holdings (Figure 1d). Thickening and drying of the stratum corneum causes the skin to crack along the wrinkles (Figure 1e). Knuckle wounds which occur on distal interphalangeal (DIP) joint and proximal interphalangeal (PIP) joint are injured by a collision with the hold or the wall (Figure 1f). Although the bleeding of these wounds is small, blood may adhere to the holds. It is somewhat difficult to stop bleeding from wounds on the fingertips and knuckles.

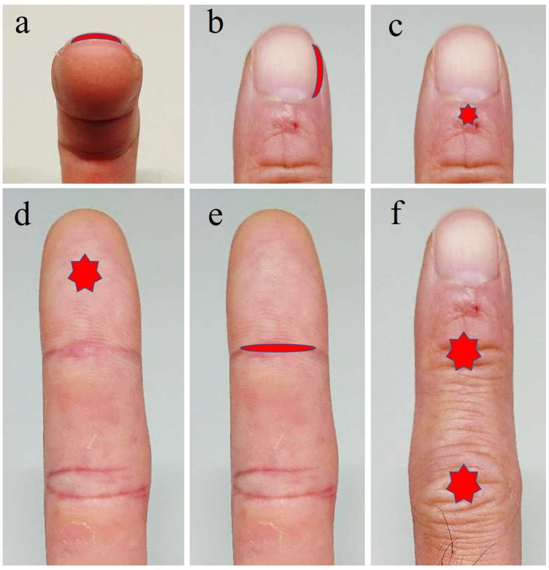

Figure 1. Frequent finger wounds

a: distal groove, b: lateral nail fold, c: proximal nail fold, d: fingertips, e: wrinkle of joint, f: knuckles

Example of treatment

A common issue in competitions is hard-to-stop or recognizable bleeding, which can be a wound on the fingertips or knuckle. In many cases, judges will ask medical staff to treat the bleeding. Upon arriving at the scene, the medical staff will wipe off the blood and the chalk around the wound with a wet towel. The wounds are less contaminated and there is no time for treatment, so the wash is not done with water. They then observe the wound and, if the bleeding does not stop, apply gauze compression. Next, they consider the time allocation and start treatment. The most important thing in treating fingertip wounds is covering wound with a material that has friction, which cannot be easily removed. As shown in the Figure 2, we use self-adherent tape such as Magic Finger Tape (evolve). For knuckle wounds, it is also important to take care to minimize the flexion by the dressing such as tape (Figure 3). With training, these procedures can be completed in a short amount of time. By showing specific treatment methods and training in advance, it is also possible to eliminate the difference in staff skills. We hope that many medical staff will refer to our method for the athletes and smooth competition management.

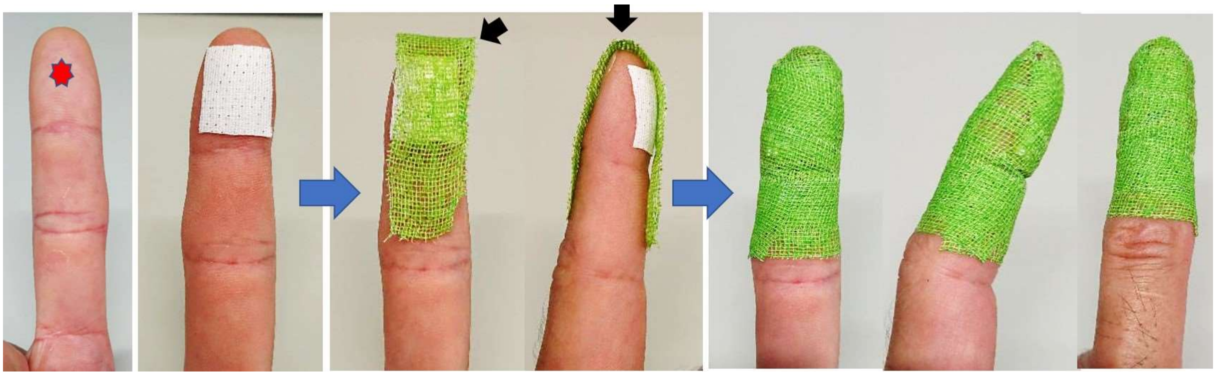

Figure 2. Treatment for fingertips wound

First, apply a tape which is slightly larger than the wound to the bleeding area. If blood oozes, add additional tape and apply. Apply Magic Finger Tape vertically, including the DIP joint. At that time, pinch the surplus (arrows) of the folding back and fold it. Wrap the same tape from the tip to the slightly peripheral part of the PIP joint. Finally, squeeze the entire finger to fit.

Figure 3. Treatment for knuckle wound

First, apply a tape which is larger than the wound to the bleeding area. If blood oozes, add additional tape and apply. Wrap a narrow tape avoiding the joint (arrows). Wrapping the tape around the joints makes it harder for the finger to bend. Be careful not to get the tape on the fingertip (arrowheads). Applying tape to the fingertip will affect the holding.

Conclusions

Here, we have explained skin problems related to sport climbing, especially finger wounds, and proposed treatments for them from the perspective of dermatologists. We have heard from athletes, judges and medical staff that the treatment of bleeding in competitions is an issue that needs to be improved. We have been involved in sport climbing for many years and have understood what to look out for. It must be kept in mind that poor treatment can have disastrous consequences for athletes. Our approach may not be perfect, but it has been successfully utilized in JMSCA-sponsored competitions. We are seeking feedback to improve it even better. Medical staff must grow together with athletes.

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IMPACT OF 30 YEARS' HIGH-LEVEL ROCK CLIMBING ON THE SHOULDER: AN MAGNETIC RESONANCE IMAGING STUDY OF 31 CLIMBERS

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Abstract

Background: Rock climbers are particularly susceptible to shoulder injuries due to repetitive upper-limb movements on vertical or overhanging terrain. However, the long-term effects of prolonged climbing on the shoulder joints are still unknown.

Purpose: The purpose of this study was to analyze the prevalence of pain and degenerative changes in the shoulder joints after high-level rock climbing over at least 25 years. We hypothesized that specific climber-associated patterns of degeneration would be found.

Methods: Thirty-one adult male high-level rock climbers were compared to an age- and sex-matched control group of 31 nonclimbers. All participants underwent a detailed interview, standardized clinical examination, and bilateral (climbers) or unilateral (nonclimbers, dominant side) magnetic resonance imaging (MRI) scans. Clinical and MRI findings of the groups were compared.

Results: The lifetime prevalence of shoulder pain in the rock climbers was 77%. The rock climbers had significantly more abnormalities in the labrum (82% vs. 52%; P = .002), long biceps tendon (53% vs. 23%; P = .006), and cartilage (28% vs. 3%; P = .005). These increased changes positively correlated with climbing intensity. There were no differences between the 2 groups with respect to rotator cuff tendon pathology (68% vs. 58%; P = .331) and acromioclavicular joint degeneration (88% vs. 90%; P = .713). Despite the increased degenerative changes in the rock climbers, their Constant score (CS) was still better than that of the nonclimbers (CS 94, interquartile range [IQR] 92-97, vs. CS 93, IQR 91-95; P = .019).

Conclusions: Prolonged high-level rock climbing leads to a high prevalence of shoulder pain and increased degenerative changes to the labrum, long biceps tendon, and cartilage. However, it is not related to any restriction in shoulder function.

CLINICAL FEATURES OF THE EPIPHYSEAL INJURY OF THE MIDDLE PHALANX IN ADOLESCENT SPORT CLIMBERS

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Abstract

Epiphyseal injury of the middle phalanx is one of the most characteristic sport injuries in adolescent sport climbers. We investigated clinical cases of this pathology and obtained some findings. Subjects were 25 fingers(17cases). 22 cases were affected in long finger and 3cases in ring finger. The mean age of onset was 14.6 years with 14 male and 3 female patients. Mean BMI was 18.3. The site of fracture was on a site of 22% to 43% from dorsal edge of the epiphysis. Primary symptoms were swelling and pain on PIP joint in all cases and interval of onset and first presentation varied from a week to four years. Conservative treatment by immobilization was indicated in principle, some delayed healings were experienced. 7 fingers in 6 cases with displacement of fragment were treated surgically. All fracture were united except an old case and a dropout case on final follow-ups and 16 cases were returned to competitions. Periods to obtain fracture union varied from two months to 2 years and 2 months. We will discuss about mechanical etiology of this specific injury and how to prevent athletes from this injury.

LONG TERM EVOLUTION OF SOFT TISSUE RESPONSE IN THE FINGERS OF HIGH-LEVEL SPORT CLIMBERS: A CROSS-SECTIONAL 10 YEAR FOLLOW-UP STUDY

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Abstract

Sport Climbing places high mechanical loads on fingers and induces physiological changes. 2012, our study group demonstrated adaptions of elite climbers` soft tissues with thicker A2/A4 pulleys, flexor tendons and palmar plates compared to non-climbers. To assess these adaptations over time we examined all 31(follow-up 100%) climbers that participated in that baseline study again using ultrasonography after a follow-up of 10 years and compared it to a non-climbing control group(n=15). Main findings:(1)In climbers, a significant increase in A2/A4 pulley and flexor tendon thickness over the last 10 years was observed($p<0.001$),while PIP/DIP palmar plate thickness remained unchanged($p<0.05$);(2)at 10-years follow-up, all soft tissue thickness parameters(incl. palmar plates)were still significantly larger in climbers than in controls($p<0.05$);(3) as for the association with anthropometrics and climbing performance/experience, a significant association of the current climber`s soft tissue thickness could only be found between palmar plate and reached climbing level($p=0.032$)as well as climber`s body weight($p=0.004$). In conclusion, an accumulation of repetitive climbing-related stress to fingers of sport climbers over the career induces mechano-adaptation of the A2/A4 pulleys, flexor tendons and palmar plates. At later stages, there is a further significant increase in flexor tendon and pulley thickness, but not for palmar plate thickness.

Key Words: athletes, hand, finger joint, connective tissue, climbing.

INTRODUCTION

Sport climbing continues to be a popular and fast-growing sport, recently included in the Olympic program for the Tokyo Summer Games. In the past a steep evolution of this sport with increased availability of climbing routes, better equipment and training facilities already took place.[17] This recent boost of popularity is likely to have influenced this development even more and will further encourage more athletes to participate in this sport earlier in life and on a higher level.[12] With newer training methods and financial support athletes nowadays are reaching higher difficulty levels and, therefore, are adding more climbing years to their bodies. Today the highest climbing level is 9c on the French scale, with a high probability that the recent development will push this limit further upwards.During climbing, the entire weight of the climber must be held with sometimes only one finger, applying extreme forces to the connective tissues.[7] The focus of climbing-related research has so far been mainly on acute climbing injuries and performance, neglecting the long-term effects to the human body after intensive climbing. Ten years ago, our study group investigated the influence of high mechanical stress from climbing on the fingers of 31 elite level sport climbers and demonstrated adaptations in connective tissues with thicker pulleys, palmar plates and flexor tendons compared to a non-climbing controls.[16] However, a potential correlation between lifelong climbing-related stress on the fingers, body weight, maximal climbing levels reached and its consequence on the soft tissues could not be investigated at that time. Therefore, the aims of this study were: (1) to sonographically assess the thickness changes of the flexor tendons, A2/A4 pulleys and PIP/DIP palmar plates in the fingers of elite sport climbers with a minimum 25 years of climbing history over the last 10-year time frame, (2) to compare these soft tissue thickness measures between elite sport climbers at the 10-year follow-up with that of age-matched non-climbing controls, and (3) to evaluate the association of the climbers' current tendon, pulley and palmar plate thickness with body weight, years of climbing, and maximally reached climbing level.

MATERIAL AND METHODS

Ten years after our baseline study on "Connective tissue adaptations in the fingers of performance sport climbers",[16] we re-invited all 31 elite rock-climbers for a follow-up investigation. At follow-up climbers were aged in average 48.3±5.0 years. Besides participation in the baseline study the inclusion criteria were being an elite level rock climber with a minimum level of 7b+ on the French scale and minimum of 25 climbing years. Exclusion criteria were quitting climbing activities, major operations or injuries to the hands or rejected informed consent. None of the climbers had to be excluded. All participants were contacted by telephone over a time-period from April to August 2019 and could be examined exactly 10 years after the baseline study (follow-up rate 100%). Controls were aged 48.1±6.1 years in average. Ultrasonography examinations were performed by either author 2 (A.S.) or author 3 (L.R.). In accordance to Schreiber et al.[16], we used an ultrasound device and the same measuring principles. Every digit of both hands except the thumb were examined at the proximal and middle phalanx. All pictures were stored, and the below aforementioned structures were measured post-hoc by means of the software implemented on the ultrasound device by the first author (T.P.) The thickness of the A2 and A4 pulleys was measured in the axial plane at the most distinct and stout location of the pulley. The flexor digitorum profundus (FDP) and flexor digitorum superficialis (FDS) tendons were visualized art their thickest point and measured combined in the sagittal plane at the level directly below the A2 and A4 pulley. The palmar plate (PP) was only displayed in the sagittal plane and thickness was measured at the proximal interphalangeal joint (PIP) and distal interphalangeal joint (DIP) between the highest part of the distal middle phalanx and the most convex part of the flexor tendons. Subsequently, all values were compared to the baseline data collected by our study group 10 years ago. In addition, data on participants' anthropometry and climbing history were collected by means of a questionnaire and were compared to the baseline study 10 years ago.The following steps of statistical analysis were performed: (1) all anthropometric and climbing-related measures were reported as mean, SD, median and range; (2) potential tendon, pulley, and palmar plate thickness differences were assessed by repeated-measures multivariate ANOVA ($p<0.05$) with Bonferroni Correction for pairwise comparisons. Within-subject factors were digit (Dig II-V) and side (right and left), between-subject factor was the group (climbers at baseline, climbers at 10-years follow-up, and age-matched controls); (2) for each parameter, digit and side detailed group differences were analysed by unpaired sample t-tests (p<0.05). Additionally, detailed group comparisons were graphically illustrated by mean and 95%CI plots; and (3) for evaluating the association of the current tendon, pulley and palmar plate thickness with the climbers' body weight, years of climbing, and maximally reached climbing level, multiple regression models were used (p<0.05).

RESULTS

The average climbing level of the climbers' group was 7c+ on the French scale (range 7b+ to 9a+). Average boulder level was 7c+ (range 7a to 8c+). Their average climbing career start was at 15.4±3.3 y (range 6.0 and 24.0 y) and overall average climbing time was 31.6±4.4 y (range 25.0 to 42.0 y). Mean body weight was 72.8±7.2 kg (range 54.0-92.0 kg) and mean body height was 1.78±0.04m (range 1.67 to 1.86 m).

Differences in soft tissue thickness

Multivariate tests revealed significant differences between the groups (p<0.001; partial eta2=0.541) and digits (p<0.001; partial eta2=0.941) but not between the sides (p=0.119; partial eta2=0.149). Interaction effects were observed for digit*side (p=0.044; partial eta2=0.406), but not for digit*group (p=0.081; partial eta2=0.346), side*group (p=0.976; partial eta2=0.034), and digit*side*group (p=0.125; partial eta2=0.332). Univariate tests with respect to group differences showed significant results for all soft tissue thickness parameters assessed (A2 tendon: p<0.001, partial eta2=0.324; A2 pulley: p<0.001, partial eta2=0.421; PIP palmar plate: p=0.001, partial eta2=0.197; A4 tendon: p<0.001, partial eta2=0.404; A4 pulley: p<0.001, partial eta2=0.413; DIP palmar plate: p=0.001, partial eta2=0.513). In climbers, pairwise comparisons indicated significant increases in A2 and A4 tendon and pulley thickness over the last 10 years (p<0.001), while PIP and DIP palmar plate thickness remained unchanged (p<0.05). At the 10-years follow-up, all soft tissue thickness parameters (incl. the palmar plates) were significantly larger in climbers than in age-matched, non-climbing controls (p>0.05).

Relationship between soft tissue thickness, age, anthropometrics, years of climbing, age at career start and maximally reached climbing level.

At the 10 years follow-up, climbers weighed 72.8±7.2 kg, had 31.6 years of climbing experience and achieved a maximum average redpoint climbing level of 13.7±2.3 (8b). At p<0.05, there were only significant associations found for average PIP/DIP palmar plate thickness of all digits and hands with body weight and the highest level in sport climbing (redpoint).

DISCUSSION

In the baseline investigation 10 years earlier, our study group reported thicker A2/A4 pulleys, flexor tendons and palmar plates in fingers of elite sport climbers compared to age matched non-climbing controls.[16] This was still the case 10 years later, and is entirely in line with earlier studies demonstrating thicker growth plates, palmar plates and flexor tendons in right middle fingers of 20 adolescent rock climbers participating in a competitive local rock-climbing team.[3] In addition, Heuck et al. demonstrated thicker capsules, collateral ligaments and up to 50% thicker flexor tendons in 20 sport climbers compared to an age-matched control group.[5] Moreover, Klauser et al. demonstrated thicker pulleys compared to a non-climbing control group.[6]As shown in the current study, there has even been a further significant increase in the thickness of A2/A4 pulleys and flexor tendons over the last 10 years.

Besides mechano-adaptation of the soft tissues, several studies demonstrated adaptations in other structures of the fingers in sport climbers. Hahn et al. described cortical hypertrophy with smaller medullary canals in elite sport climbers.[4] Similar results were published by Schöffl et al. and Bollen et al. who described cortical reactions to mechanical stress in fingers of elite sport climbers.[2, 14] Finally, our study group demonstrated a remarkable high occurrence of osteophytes and thicker cartilage in PIP and DIP joints of elite sport climbers compared to age-matched controls.[9]Last but not least, it is worth mentioning that the climbers assessed in the current study represent the study sample with the longest climbing history (25-41 years) at elite level reported in the literature to date. As such, our data suggest a career-long buildup of A2/A4 pulley and flexor tendon thickness.Although there are many studies describing mechano-adaptations in fingers of sport climbers,[1, 2, 4, 8-11, 13-16] evidence on correlations of soft tissue adaptions with anthropometry, performance level and climbing experience of climbers is scarce in the literature. To the best of our knowledge, the current study represents the first attempt to investigate interactions between these parameters. However, contrary to our hypotheses, significant correlations could only be found for palmar plate thickness with climbers' weight and maximum reached red point climbing level. On the one hand, these findings are plausible, as heavier climbers have higher forces acting on their fingers, and higher training and climbing times are necessary to reach higher redpoint levels. On the other hand, there is no reasonable interpretation as to why our data show no correlations between the other soft tissue parameters and the anthropometry, level or experience of the climbers. These partial findings make it, however, difficult to draw a general conclusion concerning correlations between climbers' soft tissue responses (tendons and pulleys) and their anthropometry, performance levels and lifetime climbing volumes. Larger study populations may fill this knowledge gap in future studies.

CONCLUSION

An accumulation of repetitive climbing-related stress to the fingers of elite sport climbers over the career may induce mechano-adaptation of the A2/A4 pulleys, flexor tendons and palmar plates. At later stages of the career, further significant increase of flexor tendon and pulley thickness but not for palmar plate thickness were observed. However, a correlation between this mechano-adaptation and the anthropometry, level and experience could only be found for palmar plate thickness with body weight as well as with highest redpoint level reached.

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HIGHER SHOE SOLE LONGITUDINAL BENDING STIFFNESS IMPROVES SPEED-CLIMBING PERFORMANCE

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Abstract

Speed climbing is a booming sport and appeared at the Tokyo Olympics in 2021. However, very few studies have focused on this discipline, especially on the influence of materials on speed climbing performance. This study aimed to evaluate the effects of Shoe Sole Longitudinal Bending Stiffness (SSLBS) on speed climbing performance. The assumptions were an improvement in performance concomitant with an increased SSLBS in ecological conditions supported by a shorter contact time and an increased covered vertical distance of the Centre of Mass (CM) after the stance phase. 8 trained participants performed 3 trials at maximum intensity on a speed climbing wall, in two randomized shoe conditions: soft and rigid sole. Using video analysis, a decrease in contact time of 9±6.4% ($p<0.05$) as well as an increase in the vertical distance covered by the CM of 3.4±3% ($p<0.05$) in rigid sole condition were reported. These results suggest an increase in climbing speed possibly contributing to enhanced performance. These results could be mainly explained by the arch compression mechanism and Windlass phenomenon, both of which are promoted by the increased stiffness of the foot. Further studies are needed to investigate the link between SSLBS and energy dissipation in speed climbing.

Keywords: Rock climbing; Contact time; Centre of mass; Ecological condition

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Introduction:

For the first time in its history, the sport of climbing will be officially present at the 2021 Olympic Games. The selected format is the combined one, a combination of the 3 subdisciplines of climbing: lead, bouldering and speed. The last one and object of interest in the present study is a timed effort on a standardized 15m vertical path. The goal is to complete the ascent in the fastest time.

Regarding speed climbing, a correlation between performance enhancement and the centre of gravity travel inside the frontal plane was reported (Reveret et al., 2018). Other studies demonstrated that in speed climbing, the performance is dictated by factors related to the lower body. (Krawczyk & Ozimek, 2014). For example, the speed climbing route includes about twenty, foot thrusts depending on the methods used. Those thrusts take place either on the holds or by adhesion, with the majority by the former. They involve an eccentric phase (damping during the impact due to gravity) immediately followed with a concentric phase.

currently, no study has investigated speed climbing performance related to shoe stiffness, and moreover in ecological conditions. However, the foot is as much an element of stabilization, of cushioning, as of propulsion (Clemençon, 2018). Several studies have highlighted the major role of the plantar fascia in energy storage and restitution, particularly in connection with the stretch-shortening cycle (Pavan et al., 2011). Climbers use rubber shoes of different shapes and stiffnesses to protect the foot, improve precision and grip, but also to stiffen the foot. Indeed, external force production requires optimal transmission and depends on the stiffness of this system. A higher stiffness might imply less loss in the transmission.

This study aimed to examine the effects of Shoe Sole Longitudinal Bending Stiffness (SSLBS) on speed climbing performance. It was hypothesized that performance would be improved with an increase in SSLBS, resulting in a shorter contact time and an increase in the covered vertical distance of the Center of Mass (CM) after the stance phase.

Methods:

8 participants (171 ± 6 cm; 62 ± 8 kg; 21 ± 4 yrs.) were recruited for this study. The participants were experts in the discipline and had no medical contraindications. The inclusion criteria were ≤ 12” on the official 15m route, or a top 50 ranking in the national federation of speed climbing for the 2019 or 2018 season. Written informed consent was obtained from all participants before their participation. This study conformed to standards from the latest revision of the Declaration of Helsinki and was approved by the local research ethics committee.

The sessions took place on a half-speed track. The same dynamic warm-up as in (Laffaye et al., 2014) study was carried out.

Similar to competition conditions, participants completed a ground-based warm-up routine. The latter stage of the warm-up comprised with three runs of increasing subjective intensity (25%, 50% and 75% of their self-estimated maximum intensity) in the half speed route (7m). A run at maximum intensity for each condition completed the warm-up and served as a familiarization phase.

Participants were asked to come with two pairs of climbing shoes, at opposite extremes in terms of SSLBS. The conditions in this study were: Soft Rubber Shoes (SR); Rigid Rubber Shoes (RR) and the SSLBS were previously checked with a home-made ergometer. Participants completed three trials for each condition, with two minutes rest between trials. The order of the conditions was randomized. For each trial, a maximal effort was required from the participant. The starting position was the reference starting position in competition, namely two hands on starting holds and right foot on the first foothold (left foot on the ground). A trial was validated only if no errors in the method, no slips, and no falls were performed.

A visual marker was fixed on the iliac crest of the participant. Video recordings were made in the sagittal and frontal plane at the height of the second foot support. The choice of analysing the n°2 foothold was based on the study by Legreneur, Rogowski and Durif (2019), which showed that the kinetic energy was maximal in the first holds of the route. The contact time and the covered vertical distance of the CM were analysed. The best trial of each condition was used for statistical analysis. After Shapiro & Wilk's test to verified normality, a student T-test for paired samples was used. Significance level was set at $p<0.05$.

Results:

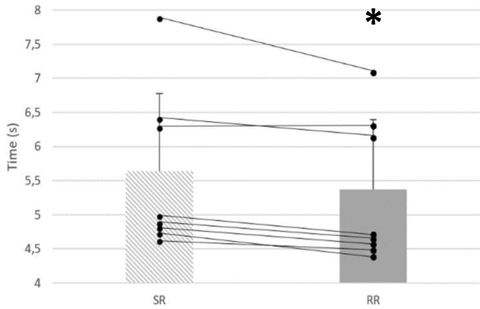

Figure 1. Travel time performance in SR and RR conditions.

A significant decrease in the travel time in RR condition was reported ($p = 0.013$), which corresponds to an increase in performance. Cohen's D is equal to 1.171 *i.e.* very important effect.

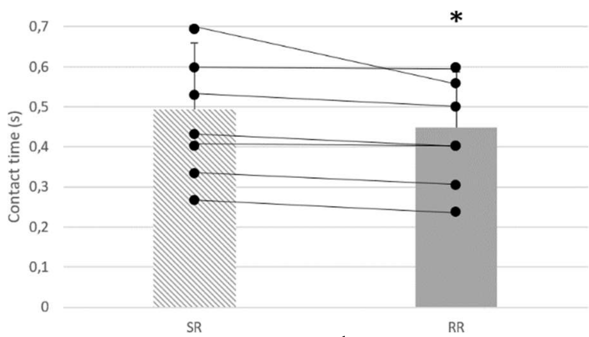

Figure 2. Contact time of the foot on the 2nd foothold in SR and RR conditions.

A significant decrease in the contact time in RR condition ($p = 0.036$) was reported. Cohen's D is equal to 0.913, *i.e.* important effect.

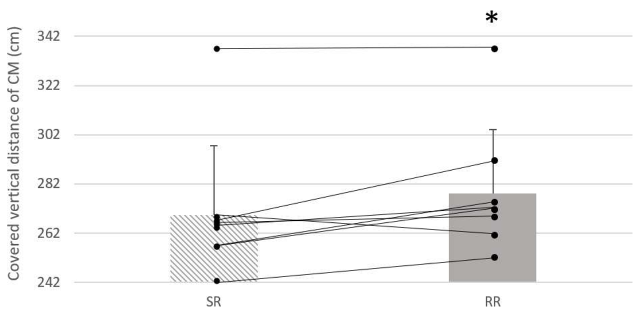

Figure 3. Vertical distance covered by the CM in SR and RR conditions.

A significant increase in the covered distance in RR condition (p = 0.045) was reported, which corresponds to an increase in speed. Cohen's D is equal to 0.863, *i.e.* important effect.

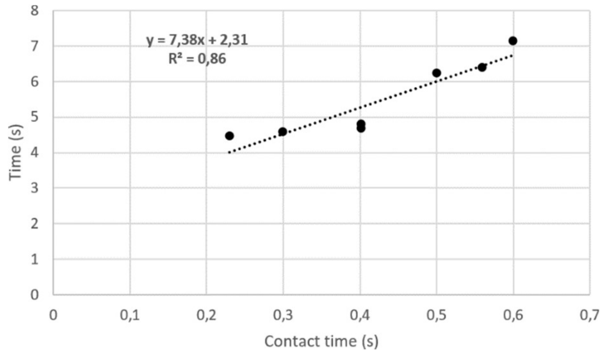

Figure 4. Correlation between the travel time performance and the contact time of the foot on the 2nd foothold.

Discussion:

This study investigated the effects of SSLBS on performance in speed climbing. It was hypothesized that increase SSLBS would improve climber's speed by a shorter contact time and a higher covered vertical distance of the CM. Results support the hypothesis that a higher covered vertical distance by the CM and a greater stiffness induced a shorter contact time. The latter is correlated with a decreased total travel time performance.

To our knowledge, no studies have focused on a link between foot mechanisms and performance in speed-climbing. However, Struzik & Zawadzki (2013) reported that stiffness appears to have a greater impact on performance in explosive sports. Speed- climbing being one of those, it could be suggested that the significant decrease in total travel time observed in the present study support this finding.

Results show an important correlation between the contact time of the foot on the second foothold and the total travel time (R^2=0.86; *figure 4*). Indeed, it was observed that the shorter the contact time, the better the performance, and vice versa. These results support previous work (Fuss & Niegl, 2006) which demonstrated that in speed climbing, speed is correlated in the same way to the contact time on the hold.

Moreover, results also demonstrated a significant reduction of contact time of the foot on the 2nd foothold by 9% by increasing the SSLBS (*figure 2*). The contact time of the foot on the foothold can be divided into two parts: a braking phase and a propulsion phase (Nigg, MacIntosh & Mester, 2000). The variations in contact time observed in this study may concern the braking phase. Indeed, increasing the rigidity of the shoe would reduce the braking time, while maintaining the propulsion phase. Arampatzis et al., (2001) have shown that increasing the stiffness of the foot improves the stiffness of the entire lower limb and promotes optimal transfer of forces. This leads to an increase in power and concomitantly in speed for the same force produced on the support. In this study this could be explained by a diminution of the dorsi-flexion of the metatarsophalangeal joint and a better energy transfer with less energy loss.

This diminution of lost energy could also explain the significant increase of covered vertical distance of the CM (*figure 4*), according to the results of Stefanyshyn & Nigg, (2000) who showed an increase of 1,7cm in vertical jump tasks with different carbon blades in the sole.

A significant decrease of 5% of total travel time (*figure 1*), as well as a higher covered vertical distance of the CM in the RR condition (*figure 3*) was also observed in the current study. this finding could be explained by grater support of the plantar fascia and medio lateral arch, inducing less energy loss and a better stretch-shortening cycle.

Further research in speed climbing should include a more precise and standardized way to evaluate the SSLBS, with more stiffness conditions in order to highlight a correlation with different parameters as the contact time, the covered vertical distance of the CM and in a more global way to performance. There is still a lack of data in the literature on speed climbing foot deformity and the underlying stretch shortening cycle mechanisms. Without speaking of morphological characteristics, an optimal stiffness seems to exist to increase performance (Butler, Crowell & Davis, 2003). These mechanisms should be validated in speed climbing, for instance by using pressure insoles, or by repeating this study using a wider range of shoes, with standardized stiffnesses.

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COMPRESSION SLEEVES IN SPORTS CLIMBING – EFFECTS ON MUSCULAR STRENGTH AND ENDURANCE PARAMETERS OF FINGER FLEXORS IN RECREATIONAL CLIMBERS

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Abstract

INTRODUCTION: Compression garments are a common intervention to improve exercise performance, but evidence on the effect on sports climbing performance is lacking. Therefore, this study aimed to evaluate effects of compression forearm-sleeves on muscular strength and endurance of finger flexor muscles.

METHODS: In a randomized crossover design, twenty-four sports climbers (12 male, 12 female; 29.1 ± 6.6 years; climbing level: 14.8 ± 1.4 IRCRA) performed one familiarization trial and three test trials either with compression forearm-sleeves (COMP), non-compressive forearm-sleeves (PLAC), or without forearm-sleeves (CON). Test trials consisted of three performance measurements (hand grip strength (HG), finger hang, and lap climbing). Near-infrared spectroscopy was used to assess the tissue saturation index (TSI). Additionally, maximum blood lactate, rate of perceived exertion, and forearm muscle pain were determined.

RESULTS: COMP significantly affected TSI in mean deoxygenation ($p = 0.049$, $\eta_p^2 = 0.194$) and reoxygenation ($p = 0.028$, $\eta_p^2 = 0.225$) phases of HG measurements compared to CON. No differences occurred between conditions for any of the performance parameters ($p \leq 0.05$).

DISCUSSION: Compression forearm-sleeves resulted in more pronounced changes of TSI during HG measurements indicating increased blood circulation and venous return, but did neither enhance muscular strength nor endurance of finger flexor muscles.

Keywords: sports climbing, wrist flexor muscles, work fatigue, grip strength, forearm

A CASE STUDY OF A SPORT-CLIMBER WHO WAS ABLE TO SIGNIFICANTLY IMPROVE LEAD PERFORMANCE IN A SHORT PERIOD USING HIGH-INTENSITY INTERVAL TRAINING METHODS

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Abstract

Introduction : In a previous study, the authors have developed two simple test methods for measuring finger muscle strength and its endurance . In this case study, we use the tests to evaluate the characteristics of one male intermediate level competitive climber, and prescribed "climbing specific high-intensity interval training" program (HIIT-C) to improve his lead performance in a short period.

Methods : The subject trained the HIIT-C for 2 months. In the training, he moved a climbing wall with high intensity phase (90% peak HR) and following low intensity phase alternately. He repeated those two phases 3 times in a set and finished 2-3 sets total with 15-20 mins breaks in between (*Figure 1.*). Heart rate (HR), rating of perceived exertion (RPE), and visual analog scale of fatigue sense (VAS-F) were measured at every set to exercise adequate intensity.

Results & Discussion : The subject's lead performance improved from 5.11c (intermediate level) to 5.12d (advanced level) in 3 months. And the RPE and VAS-F decreased when climbing the same route (*Figure 2.*). Finger strength increased up to 15 kg (31%) after the training. In conclusion, the HIIT-C training method is useful for improving lead climbing performance in a short period.

Keywords Sport-climbing, Performance, High-intensity interval training, Heart rate

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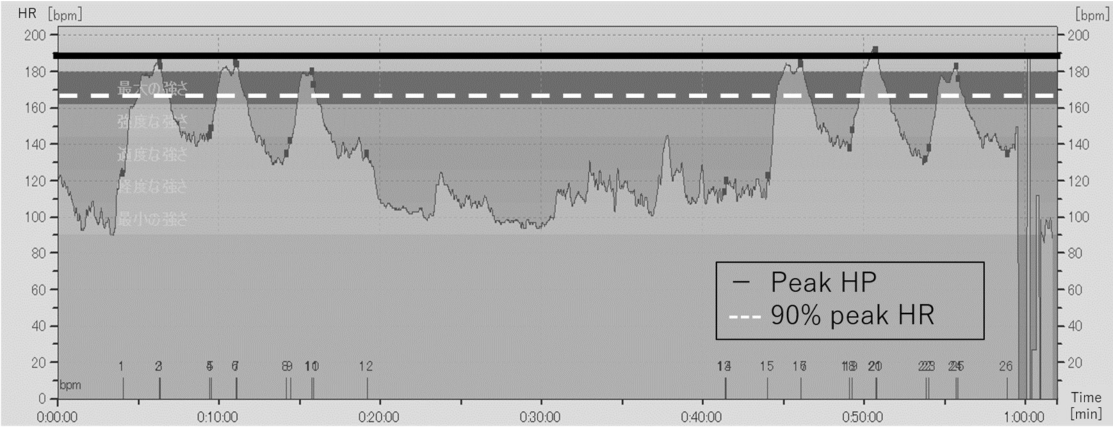

Figure 1. Heart rate variability during HIIT-C

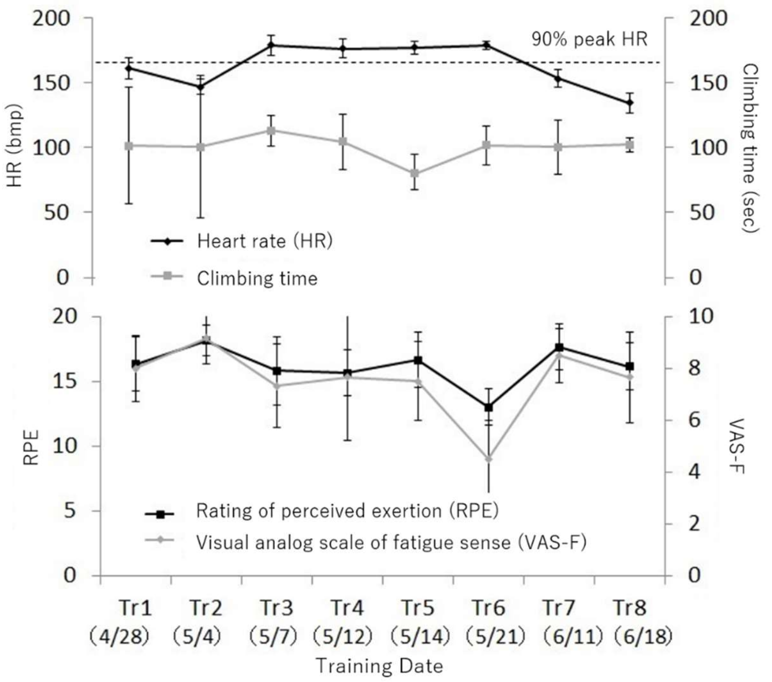

Figure2. Transition in each physiological responses in high intensity phase

VIDEO ANALYSIS OF THE MEN'S BOULDERING WORLD CLIMBING CHAMPIONSHIP PERFORMANCE

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Abstract

The study aims to determine the parameters of the bouldering competition associated with the sports performance of athletes. 97 athletes were filmed during the qualifying round of the Bouldering World Championships (2018, Innsbruck and 2019, Hachioji). A total of 318 runs were analyzed to identify the parameters of the competition. Data collection included viewing time, the number of attempts per top and zone, total attempts, total and average number of hand grips, work and rest times, average attempt and rest times, climbing and recovery times. Statistically significant differences at p = 0.05 and a correlation with the athletic performance of climbers are observed for the same parameters of bouldering competitions. On average, elite bouldering climbers spend 1 attempt to reach the zone and 1-2 attempts to reach the top. The attempt time for these athletes is 22-28 seconds, and the number of grips is from 6-8 grip with the hands. Climbing time is usually 40-124 seconds of which 0-45 seconds is rest between attempts. The recovery time to the next route is 152-209 seconds. Video analysis made it possible to find informative parameters of bouldering competitions for elite athletes. In future studies, these parameters of competition should be compared with the physical fitness of climbers.

Keywords: rock climbing; monitoring sport performance; parameters of the bouldering competition.

Introduction

In 2010 the International Olympic Committee recognized rock climbing as an Olympic sport. The youngest competitive climbing discipline is bouldering, which is based on the passage of a series of short, extremely difficult routes. The classic format of bouldering competition is a closed type of routes on special climbing walls. All problems are always unique and have a different category of difficulty depending on the rank of the competition being held (Seifert, Wolf & Schweizer, 2017). The IFSC Bouldering World Championship consists of three rounds: a qualification round with 5 problems, semi-final, and final rounds with 4 problems. The number of attempts to climb the problem is not limited, but the time for completing the problem in the qualification and semi-final rounds is standardized 5 minutes and in the final - 4 minutes. The rest period between two problems is equal to the climbing time. The results of the competition are determined by the total number of attempts and the number of tops and zones. The best result in the round is shown by the athlete who covered the maximum number of problems, spending the minimum number of attempts.

In our opinion, one of the main problems of sports training for climbers is the lack of theoretical knowledge about monitoring the performances of athletes in new Olympic sports. The most popular areas of research among scientists are the special physical training of climbers, the construction of the training process, sports psychology, injuries and safety in rock climbing (Dovgalecs, Boulanger, Orth, Herault, Coeurjolly & et all., 2014; Hörst, 2003). To date, we have found 3 international articles and abstracts devoted to monitoring the performance of rock climbers in bouldering competitions (La Torre, Crespi, Serpiello, & Merati, 2009; Medernach, Kleinöder, & Lötzerich, 2016; White & Olsen, 2010). Nevertheless, these works have shortcomings and limited applicability for monitoring competitive activity (McGuigan, 2017). In this regard, it was decided to conduct a scientific study to develop monitoring of the performance of rock climbers in the discipline of bouldering.

Methods

Subject

To identify the parameters of the bouldering competition, we analyzed the competitive performances of 97 male climbers in the qualification round of the Bouldering World Championships (Austria, Innsbruck, 2018 and Japan, Hachioji, 2019). All athletes were divided into two comparative groups. The first group consisted of the participants who took the 1st to 20th place in the World Championship standings (n=38). This group was represented by 18 climbers at the World Bouldering Championship in 2018 and 20 athletes in 2019. It is interesting to note that 11 athletes have participated in both Bouldering World Championships such as Chon Jongwon, Cornu Manuel, Fujii Kokoro, Harada Kai, Hojer Jan, Kruder Jernej, Narasaki Tomoa, Ogata Yoshiyuki, Ondra Adam, Phillips Nathan, Schubert Jakob. The second group included all other athletes who could not reach the semi-final of the competition (n=59). In total, 318 routes were analyzed in two Bouldering World Championships, of which 149 routes were climbed by athletes in the first group and 169 routes in the second group.

Procedure and data collection

The parameters of the bouldering competition were recorded using video filming. A Sony FDR-AX53 4K Ultra-HD video camera (Sony Corporation, Tokyo, Japan) with a shooting frequency of 50 fps was fixed on a tripod at a distance of 10–20 m from the bouldering wall. Video filming was carried out with sufficient illumination without disturbing the competitive process. The movements of the athletes during the climbing route were analyzed using the footage of the bouldering competition using observation methods to collect data. We recorded for each climber's attempt parameters such as the time of the attempt (the time from the starting position to reaching the top or the athlete's fall from the hold), the number of grips (the total number of grips with the hands performed in one attempt), and the rest time (the time from the moment of the end of one attempt and before the next).

Additionally, we allocated the viewing time (the time from the signal until the athlete took the starting position and the start of the first attempt), the number of attempts per zone (the number of the attempt on which the athlete reached the zone's hold) and the number of attempts per top (the number of attempts the athlete needed to reach the finishing hold top with two hands) for each bouldering route. If the athlete failed to reach the top or the zone, the total number of attempts plus one was used for statistical analysis.

The above parameters of the bouldering competition allowed us to calculate the following parameters:

- number of attempts - the total number of attempts while climbing the route,
- total number of grips - the number of hand grips for all attempts on the route,
- average number of grips - the ratio of the total number of grips to the number of attempts,
- working time - total time of attempts on the route,
- rest time - total rest time between attempts on the same route, excluding viewing time and recovery time,
- average attempt time - the ratio of the work time to the number of attempts,
- average rest time - the ratio of rest time to the number of attempts minus one, because the rest time after the last attempt is not taken into account,
- climbing time (time from the starting position of the athlete to the end of the last attempt),

- recovery time (time from the end of the last attempt to the final signal).

Statistical Analyses

Statistical analysis was performed using Microsoft Excel 2016 (Microsoft Corporation, USA). The first step of the statistical analysis was to assess the normal distribution of bouldering competition parameters using the Chi-square, Liliefors and Shapiro-Wilko tests. In the study, it was found that the viewing time of the route follows a normal distribution according to three statistical criteria. Thus, it can be assumed that this parameter is a random variable, which is not influenced by any factors (skill level, athlete's fitness, etc.). The normality of data distribution for other parameters of bouldering competition was rejected by all statistical criteria. Therefore, we used nonparametric methods of mathematical statistics for data analysis.

Descriptive data statistics are presented as median (Me), upper quartile (Q0.75), and lower quartile (Q0.25). Bouldering competition parameters were compared to identify statistically significant differences. For this, the Mann-Whitney test (U) was applied at a significance level of 0.05 for two independent samples.

Spearman's rank correlation coefficient was used to determine the relationship between the parameters of bouldering competitions and the sports results of athletes.

Results

Descriptive data and statistically significant differences in bouldering competition parameters are described in Table 1. Comparative analysis of the values showed that statistically significant differences at $p = 0.05$ were found in the number of attempts, the number of attempts per top and zone, the average number of grips and rest time, the average attempt time, climbing time, and recovery time.

The correlation analysis of the competitive parameters with the climbers' sports results is presented in Table 2. Sports results were expressed by the place in the World Championship table and the place in the group after the qualification round of the World Championship. Thus, it was revealed that the same competitive parameters in bouldering are statistically significantly different and have a moderate correlation with the sports results of climbers.

Table 1. Analysis of the competitive parameters of male rock climbers at the World Bouldering Championship

Indicators	**N**	**Group**	**Q 25%**	**Me (50%)**	**Q 75%**	**p**	
Viewing time	149	Semi-finalist group	31	42	53	0,30543	p>0,05
	169	Non-Semi-finalist group	27	40	51		
Number of attempts per zone	149	Semi-finalist group	1	2	4	**0,00000**	**p<0,05**
	169	Non-Semi-finalist group	1	4	7		

Number of attempts per top	149	Semi-finalist group	2	4	5	**0,00000**	**p<0,05**
	169	Non-Semi-finalist group	4	6	8		
Number of attempts	149	Semi-finalist group	2	3	5	**0,00000**	**p<0,05**
	169	Non-Semi-finalist group	4	5	7		
Total number of grips	149	Semi-finalist group	11	16	23	0,07599	p>0,05
	169	Non-Semi-finalist group	13	18	25		
Average number of grips	149	Semi-finalist group	4	6	8	**0,00000**	**p<0,05**
	169	Non-Semi-finalist group	3	4	6		
Working time	149	Semi-finalist group	35	51	75	0,13255	p>0,05
	169	Non-Semi-finalist group	36	56	85		
Rest time	149	Semi-finalist group	15	108	153	**0,00000**	**p<0,05**
	169	Non-Semi-finalist group	99	144	180		
Average attempt time	149	Semi-finalist group	12	19	27	**0,00000**	**p<0,05**
	169	Non-Semi-finalist group	7	12	21		
Average rest time	149	Semi-finalist group	15	33	49	0,59828	p>0,05
	169	Non-Semi-finalist group	22	33	43		
Climbing time	149	Semi-finalist group	52	170	229	**0,00002**	**p<0,05**
	169	Non-Semi-finalist group	177	218	240		
Recovery time	149	Semi-finalist group	30	96	204	**0,00004**	**p<0,05**
	169	Non-Semi-finalist group	23	40	71		

Table 2. Correlation analysis of competitive parameters with sports results of male climbers in bouldering (n = 318; $p_{crit} = 0.105$; p = 0.05)

	Place in the World Championship	**Place in the group**
Viewing time	0,01	0,03
Number of attempts per zone	**0,36***	**0,39***
Number of attempts per top	**0,46***	**0,50***
Number of attempts	**0,44***	**0,47***
Total number of grips	0,10	**0,12***
Average number of grips	**-0,44***	**-0,47***
Working time	0,06	0,07
Rest time	**0,35***	**0,39***

Average attempt time	**-0,36***	**-0,39***
Average rest time	0,07	0,08
Climbing time	**0,29***	**0,33***
Recovery time	**-0,28***	**-0,31***

***** - *significant correlation coefficient at p <0.05*

Discussion

Based on this study, it can be concluded that male climbers who reached the semifinals of the World Championship reach the bonus hold Zone (from 2 attempts) and the finish hold Top (from 4 attempts) faster. Accordingly, the climbing time (170 seconds) and the rest time between attempts (108 seconds) will be shorter, but the recovery time (96 seconds) after passing the route will be longer. However, the average attempt time (19 seconds) and the average number of grips (6 hand grips) will be higher because they reach a higher hold on the attempt.

It can be concluded that the athletes were more successful in reaching the Top on their first attempt at the Bouldering World Championships in 2019. However, the climbing time could be from 15 to 65 seconds. For example, Tomoa Narasaki took 15 seconds to complete the route, while Jongwon Chon completed the same route in 47 seconds. However, both athletes performed the same number of hand grips, equal to 6. The same pattern is observed on the other route, where the climbing time of Tomoa Narasaki was 35 seconds, and Jongwon Chon was 65 seconds with the same 6 hand grips. The rest time between attempts will be 0 seconds and the recovery time before starting the next route will reach the maximum values (204-253 seconds).

The opposite situation can be when an athlete manages to reach the Top and the Zone with 5 attempts, where the average attempt time can be 9-10 seconds like Adam Ondra or Kokoro Fujii, the number of grips is also reduced to 4 hand grips, while the rest time between attempts is a significant part of the time 103 and 72 seconds, respectively. As a rule, the longest rest time between attempts, from 140-160 seconds, is observed in athletes who have not reached the top finish hold. Thus, the recovery time for these athletes will be less than 24-43 seconds.

Table 3 shows the individual profile of the 4 elite athletes in the informative parameters of the bouldering competition. The data is described by a measure of central tendency (median) from the qualification round of the Bouldering World Championships in 2018 and 2019.

Table 3. Individual Profile of 4 Elite Athletes Bouldering Competition at the 2018 and 2019 World Championships.

Athlete's name	**Number of attempts per zone**	**Number of attempts per top**	**Number of attempts**	**Average number of grips**	**Rest time**	**Average attempt time**	**Climbing time**	**Recovery time**
Chon Jongwon	1	1	1	8	0	28	65	205
Fujii Kokoro	1	2	2	7	45	22	124	152
Narasaki Tomoa	1	2	2	6	36	22	77	199

Ondra Adam	1	1	1	6	0	26	40	209

Elite bouldering climbers spend 1 attempt to reach the zone and 1-2 attempts to reach the final Top hold. The attempt time for these athletes is 22-28 seconds, and the number of grips with the hands is from 6-8 grip with the hands. Climbing time is usually 40-124 seconds of which 0-45 seconds is rest between attempts. The recovery time to the next route is 152-209 seconds.

Conclusion

The practical significance of the research will allow the coach to objectify the level of technical and tactical skills of climbers and quickly form a tactical plan for passing the route. It can be assumed that elite athletes achieve similar parameters of bouldering competitions due to their high physical fitness. In this regard, future studies should compare the parameters of the climbers' performance with the physical fitness of the athlete to confirm the hypothesis.

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List of Participants

(Invited speakers, Live &Video presenters, full 4-day participants, and Organisers)

1 Greeting Day1DAIROKUNO Kosaku (Japan)
2 Plenary Day1, General 1.1.3, 1.1.4, 1.2.3SCHÖFFL Volker (Germany)
3 Plenary Day2, General 2.1.4, Organiser ESPAÑA-ROMERO Vanesa (Spain)
4 Plenary Day3, Organiser REED Taylor (United States)
5 Plenary Day4KOBINATA Toru (Japan)
6 Special report Day 1HIRAYAMA Yuji (Japan)
7 Special report Day 2AMMA Sachi (Japan)
8 Special report Day 3KOBAYASHI Koichiro (Japan)
9 Special report Day 3, Organiser HARIGAYA Masako (Japan)
10 Special report Day 3, Organiser MIZUMURA Shinji (Japan)
11 Olympic Day 4 KRAJNIC Roman (Slovenia)
12 Olympic Day 4 MILOSLAW Mateusz (Poland)
13 Olympic Day 4 STOCKER Urs (Switzerland)
14 Olympic Day 4 YASUI Hiroshi (Japan)
15 General 1.1.2 NEUMAIER Michael (Germany)
16 General 1.2.1 SCHWEIZER Andreas (Switzerland)
17 General 1.2.2 DESTEFANO Matt (United States)
18 General 1.2.4 VAGY Jared (United States)
19 General 2.1.1 ANDRI Feldmann (Switzerland)
20 General 2.1.2 LÓPEZ-RIVERA Eva (Spain)
21 General 2.1.3 PHILLIPS C Kevin (United States)
22 General 2.2.1 GALVEZ RUIZ David (Spain)
23 General 2.2.2, 4.1.1 WITTMANN Frieder (Switzerland)
24 General 2.2.3 WOLF Peter (Switzerland)
25 General 2.2.4 COLOMBO Alessandro (Italia)
26 General 3.1.1 SCARFF Dean (Australia)
27 General 3.1.2 IONEL Maria Stefania (Romania)
28 General 3.1.3 JULIA M Epelde (Spain)
29 General 3.2.1 CARTER P David (United States)
30 General 3.2.2 CASUCCI Tallie (United States)
31 General 3.2.3, 4.2.3GARRIDO-PALOMINO Inmaculada (Spain)
32 General 3.2.4 VARDY Jamie (United Kingdom)
33 General 4.1.2 COELHO Antonio Jose (Portugal)
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41 General V03 BEELER Silvan (Switzerland)
42 General V04 ROKKAKU Tomoyuki (Japan)
43 General V05 PASTOR Torsten (Switzerland)
44 General V06 KOTCHENKO Yury (Russia)
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46 General V08 LIMMER Mirjam (Germany)
47 General V09 NISHITANI Yoshiko (Japan)
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75 MICHAEL Marisa (United States)
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82 TALLIE Casucci (United States)
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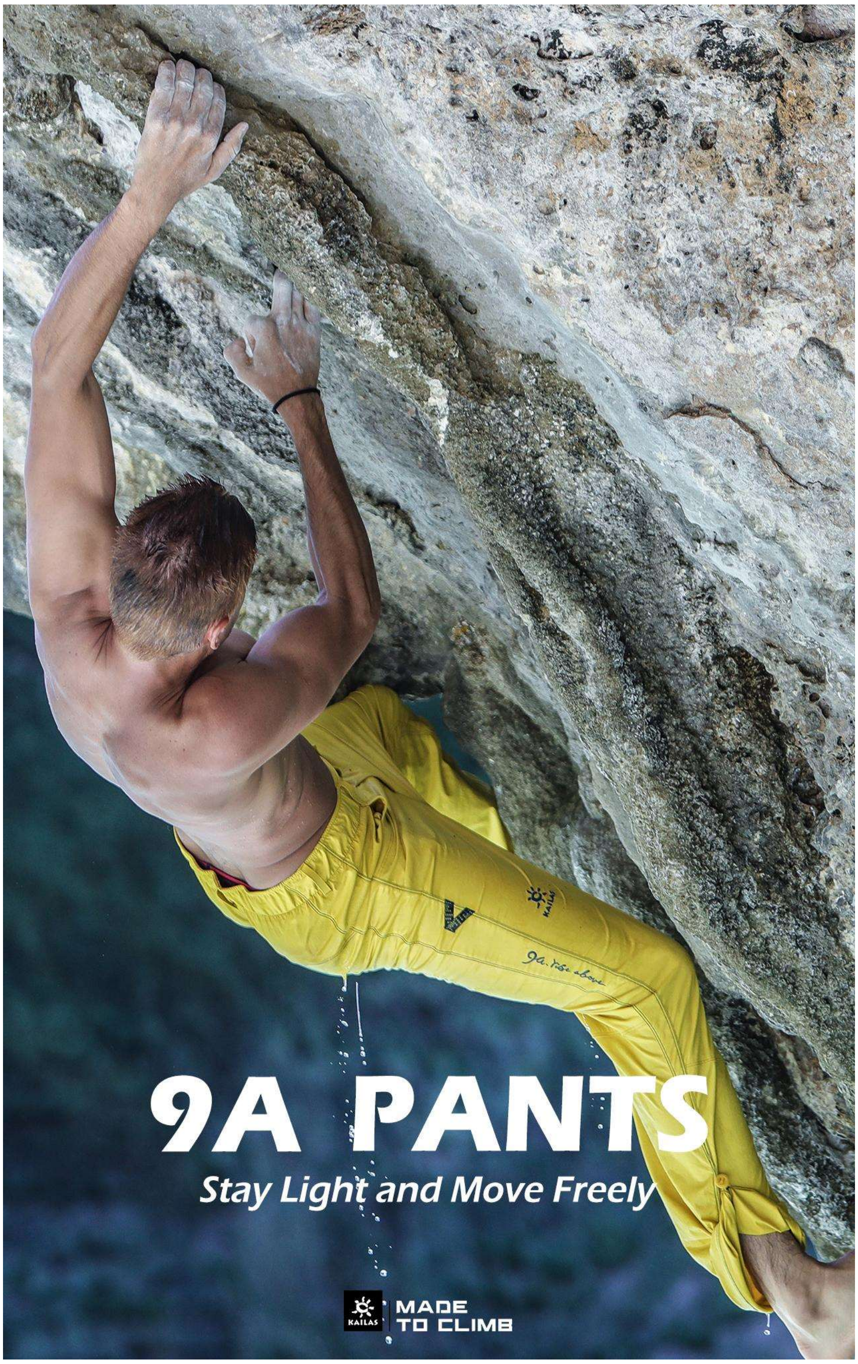
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