Original research article

International Journal of Sports Science & Coaching

Profiling of expert bouldering routesetters

International Journal of Sports Science & Coaching
1–9

DOI: 10.1177/17479541241248583
journals.sagepub.com/home/spo
Sage

Julian Henz[1], Xavier Sanchez[2,3,4], Daniel Memmert[1], and Jerry Prosper Medernach[1,5]

Abstract

Introduction: Bouldering is an Olympic discipline that takes place on low-height climbing structures known as boulders. Routesetters play a critical role in bouldering; they design and set boulders to be climbed, which must be original, safe to climb and adapted to climbers' levels. Considering the critical role routesetters play to keep the present success and ensure the future development of bouldering, the purpose of this study was to profile expert routesetters by identifying relevant key skills they possess and examining specific strategies they use when designing boulders.

Methods: Seventy-eight expert routesetters completed an online survey structured in eight sections that assessed the following: perceptual–cognitive skills; soft skills; motor skills; climbing skills; welfare; safety and difficulty; climbing holds and wall features; and climbing movement diversity and boulder styles.

Results: Among fundamental skills experts identified, most relevant to routesetters were possessing a broad climbing movement repertoire, the ability to develop several climbing strategies for one boulder, forecasting of climbing movements, climbing-specific decision-making and creativity, self-reflection, teamwork, dealing with negative feedback, technical skills and general fitness. Furthermore, most relevant specific routesetter skills and strategies appeared to encompass the ability to design boulders that account for climbers' skill levels and safety, to adapt to the constraints of climbing gyms, to make optimal use of climbing wall features and to design versatile climbing movements.

Conclusion: The expert routesetters' profile comprises fundamental and specific skills and strategies that enable them to design target-oriented boulders with versatile climbing movements for different levels whilst accounting for climbers' welfare.

Keywords

Climbing, cognition, decision-making, expertise, skill, strategy

Bouldering is an Olympic climbing discipline (the other two are lead climbing and speed climbing) that takes place on low-height artificial climbing structures known as boulders.[1,2] Routesetters design and set these boulders by placing climbing holds of various sizes and shapes on those low-height artificial climbing walls.[3,4] Although boulders are relatively short in length, with an average of four to eight climbing holds,[1] the climbing movements involved in bouldering are typically strenuous, athletic and gymnastic, implying a high probability of falling during attempts.[5] Despite the increasing professionalisation of bouldering,[6] knowledge on routesetters is non-existent though they play a critical role in the success of bouldering by ensuring climbers' welfare, providing movement versatility and adapting climbing movements to the climbers' levels. Therefore, it is necessary to profile expert routesetters by identifying their relevant key skills and examining specific strategies they use when designing boulders to maintain the current success and ensure the future development of bouldering.

In climbing, performance is typically associated with multiple determining factors.[7] In addition to outstanding technical[8] and motor skills,[9] recent research stresses the pivotal role of perceptual and cognitive skills in climbing and bouldering, such as route previewing,[10] a broad

Reviewer: Cécile Martha (Aix-Marseille University, France)

[1]Institute of Exercise Training and Sport Informatics, German Sport University Cologne, Cologne, Germany
[2]CIAMS, Université d'Orléans, Orléans, France
[3]CIAMS, Université Paris-Saclay, Orsay, France
[4]SAPRéM, Université d'Orléans, Orléans, France
[5]National Institute of Physical Activity and Sports, Luxembourg-City, Ministry of Sport, Luxembourg

Corresponding author:
Jerry Prosper Medernach, Institute of Exercise Training and Sport Informatics, German Sport University Cologne, am Sportpark Müngersdorf, D-50933 Cologne, Germany.
Email: research@climbing.science

repertoire of climbing movements,[11] strategic motor planning[12] and decision-making skills.[5] Research has also shown that psychological factors such as flow and clutch states,[13] pre-performance anxiety[14] and mental states,[15] as well as social skills such as communication with peers during route previewing[11] are critical to good climbing performance. While key performance parameters in climbing are reasonably known,[11,16] the extent to which they are also relevant and of use to routesetters – regardless of the climbing modality – remains unknown.

Despite inherent similarities between routesetting in lead climbing and bouldering, the present paper focuses on routesetters and routesetting in bouldering. Profiling the skills routesetters need and the strategies they use in bouldering is particularly relevant, given the specific characteristics of bouldering: the low-height of bouldering walls (4.5 m) and the limited number of climbing movements. Such specificity of routesetting in bouldering challenges routesetters in the designing and setting of boulders.[3]

The design of such boulders also depends upon the context in which bouldering takes place. Within the competitive context, for instance, routesetters must ensure audience-friendly and fair competitions with an equal level playing field for all competitors.[17] Conversely, in the recreational context, routesetters must design boulders for a broad range of climbers of varying skill levels[3] that promote self-efficacy, enjoyment and learning processes.[18] However, regardless of the routesetting context, ensuring climbers' safety by limiting the risk of injury when falling off remains a fundamental aspect of routesetting in bouldering.[1] For example, rules of the International Federation of Sport Climbing (IFSC) specify that routesetters must adapt the number of boulders they set and the climbing movement they design to the safety mats to guarantee adequate landing areas.

Increasing safety standards and an infinite number of climbing holds varying in size and shape allow routesetters to continually explore new styles and design creative boulders that require surprising and original climbing strategies.[17,19] Specifically, style refers to the prevailing climbing movements of boulders,[3] which are determined by the slope of the climbing wall and how routesetters place climbing holds on the wall. Augste et al.[3] examined the types of boulders at the finals of IFSC competitions and observed five main styles: (a) *dynamo* boulders with athletic jumping movements; (b) *volume* boulders including large, three-dimensional climbing surfaces typically made from wood; (c) *crimp* boulders in which finger strength is decisive; (d) *slab* boulders with high balance requirements; and (e) *mantle* boulders including stemming climbing movements.

To ensure diversity of climbing movements, routesetters can rely on the RIC-scale,[17] a five-point Likert scale (1: very low; 5: very high) that assigns three distinct dimensions to boulders, namely the *risk* dimension (i.e. difficulty of controlling climbing movements), the *intensity* dimension (i.e. physical aspect of the climbing movements) and the *complexity* dimension (i.e. difficult to figure out the movements). Some routesetters extend the RIC-scale by including the *originality* dimension (i.e. RICO-scale), which rates the rareness, unpredictability and creativity of the climbing movements.

Despite the critical role routesetters play in bouldering, very little is known about who they are and what they consider as key to successfully develop their job. Therefore, the purpose of the present study was to profile expert routesetters by identifying relevant key skills they possess and examining specific strategies they use when designing boulders. That is, drawing on key performance parameters identified in sport climbing,[7,11] extending on previous research in routesetting[4] and based on recent specific recommendations for routesetting in modern bouldering,[17] this study was developed to gather knowledge and understanding related to the fundamental and specific skills and strategies relevant to routesetting in bouldering as perceived by expert routesetters.

Materials and methods

Participants

Inclusion criteria for participation in the survey were that participants (a) have been working for at least 10 years as professional routesetters (i.e. at least several times a month as main or secondary job), (b) possess a routesetting certification (i.e. at least one further training course), (c) have at least an advanced level of bouldering (19 points on the IRCRA scale; Draper et al.,[20] and (d) have at least 10 years of bouldering experience. Seventy-eight male routesetters from 16 different countries complied with these requirements and volunteered to participate in the survey (see Table 1). On average, participants had an elite IRCRA level, 20 years of bouldering experience, and 14 years of routesetting experience (see Table 1). Most of the participants reported having experience as routesetters in national or international competitive bouldering (87.2%), had competed as climbers in bouldering competitions (67.9%), and had trained other routesetters (65.4%). Linear regression analysis revealed a positive effect, with $F(1,76) = 131.7$; $p < 0.001$; $R^2 = 0.63$, between the participants' bouldering and routesetter experience in years, with $\beta = 0.80$; 95% CI: [0.47, 0.66]; $p < 0.001$. Multiple linear regression analysis indicated a positive effect, with $F(2,46) = 11.8$; $p < 0.001$; $R^2 = 0.31$, between the participants' experience as routesetters in competitive bouldering (dependent variable) and both their routesetting experience, with $\beta = 0.35$; 95% CI: [0.11, 0.68]; $p = 0.009$, and their experience as competitive boulderers, with $\beta = 0.35$; 95% CI: [0.90, 0.57]; $p = 0.008$. Participants provided written informed consent and were informed about the purpose of the study. The study received ethical approval from the University Ethics Committee (ID 211/2022) and was conducted in conformity with the World Medical Association.

Table 1. Personal characteristics, bouldering expertise and routesetting background of the routesetters.

Variables	*n*	min	max	*M*	*SD*
Age (years)	78	24.0	53.0	35.7	6.2
Weight (kg)	78	50.0	100.0	73.0	9.5
Height (cm)	78	150.0	193.0	177.8	7.3
IRCRA (score[a])	78	19.0	30.0	24.2	2.8
Bouldering experience (years)	78	10.0	39.0	19.7	6.5
Experience as competitors (years)	53	1.0	26.0	7.9	5.5
Routesetting experience (years)	78	10.0	28.0	13.9	4.6
Competitive routesetting experience (years)	68	1.0	24.0	8.7	5.1

Note: Results include the number of participants (*n*), the lowest (min) and highest (max) value for each variable, followed by the mean (*M*) and standard deviation (*SD*).

[a]International Rock Climbing Research Association's numerical scale for classifying climbing skills (novice: ≤10 points; intermediate: 11–17 points; advanced: 18–23 points; elite: 24–27 points; world-class: ≥28 points).

Design of the survey

Data collection was conducted via a 70-item online survey structured in different sections. Following the consent form and information section about the purpose of the survey, the routesetters' personal characteristics, sport-specific experience and routesetting background were assessed (section 1 with 13 items). The second section was developed based on previously identified key performance parameters in climbing[7,11] and included five categories that aimed at assessing fundamental routesetter skills: (1) seven items on perceptual–cognitive skills; (2) nine items on soft skills; (3) eight items on sport-specific motor skills; (4) four items on climbing skills; and (5) five items on welfare. Specifically, following Künzell et al.[12] and Medernach and Memmert,[5] items on perceptual–cognitive skills included the decision-making skills and creativity of routesetters, their repertoire of climbing movements, their ability to visualise and mentally anticipate climbing movements, and their ability to develop appropriate and alternative climbing strategies. Extending Cotterill and Fransen,[21] Davis et al.[22] and Ntoumanis et al.,[23] soft skills were defined as personal behavioural attributes that exceed routesetting expertise, such as being self-reflective, dealing with negative feedback, teamwork, communication, or time management. Drawing on Fryer et al.[8] and Baláš et al.,[9] the sections on motor and climbing skills included items regarding sport-specific skills such as finger strength, upper body power, footwork or movement coordination (see Figure 1). The third section was drawn on climbing movement characteristics of modern boulders[17] and included three categories that aimed at assessing specific routesetter skills and strategies: (6) nine items on safety attributes and the difficulty of boulders; (7) seven items on climbing holds and wall features; and (8) eight items on climbing movement diversity and boulder styles.

Participants were asked to rate each item by ticking the appropriate box on a six-point Likert scale (ranging from 1: I agree not at all to 6: I fully agree). Specifically, they were instructed to rate the relevance of each item to their work as routesetters in general, regardless of whether they are setting in the competitive or recreational context. The survey took on average approximately 15 min to complete.

Validation and reliability of the measures

Only participants who fully completed the survey and confirmed that they understood and accurately completed each part of the questionnaire were considered for data analysis. Five scientists with routesetting qualifications (European Qualifications Framework: level 3), a considerable number of years of climbing practice (15 ± 4 years), and an advanced level of bouldering (21–23 IRCRA points) were commissioned to design, validate and ensure the reliability of the survey. Following its initial design, each of them independently examined the comprehensibility, consistency and clarity of the items; in case of ambiguity, items were adapted as necessary. A test–retest reliability analysis with 30 routesetters as participants (excluded from the main study sample) with varying bouldering levels and routesetting expertise showed high consistency ($r \geq 0.85$) and confirmed the reliability measures. Cronbach's Alpha revealed high consistency for category 1 ($\alpha = 0.83$), category 2 ($\alpha = 0.90$), category 3 ($\alpha = 0.87$), category 4 ($\alpha = 0.72$) and category 5 ($\alpha = 0.76$). Cronbach's Alpha was not calculated for the categories 6 to 8, as assigning separate items to a superordinate section would have been inconclusive.

Statistical analysis

IBM SPSS Statistics 29 (IBM Corporation, USA) was used for statistical analyses. A priori power analysis for the Pearson's chi square test revealed an effect size of $\omega = 0.369$, with a sample size of 78 participants, $df = 1$, an α of 0.05, and a power of 0.9. Results are indicated as percentages or as mean values and standard deviations ($M \pm SD$) for interval-scaled variables. Pearson's chi-squared tests were used to determine differences between the expected and observed frequencies, by clustering the participants' responses into two categories: category 1 'I disagree', including the answers ranging from one to three on the Likert scale, and category 2 'I agree', including the answers ranging from four to six on the Likert scale (i.e. percentages for each section are indicated in brackets). Cohen's ω was calculated as a measure for the effect size. Cronbach's α was calculated for analysis of reliability. For multiple regression analyses, an analysis of variance (ANOVA) was calculated, including Nagelkerke's R^2 as a measure for effect size.

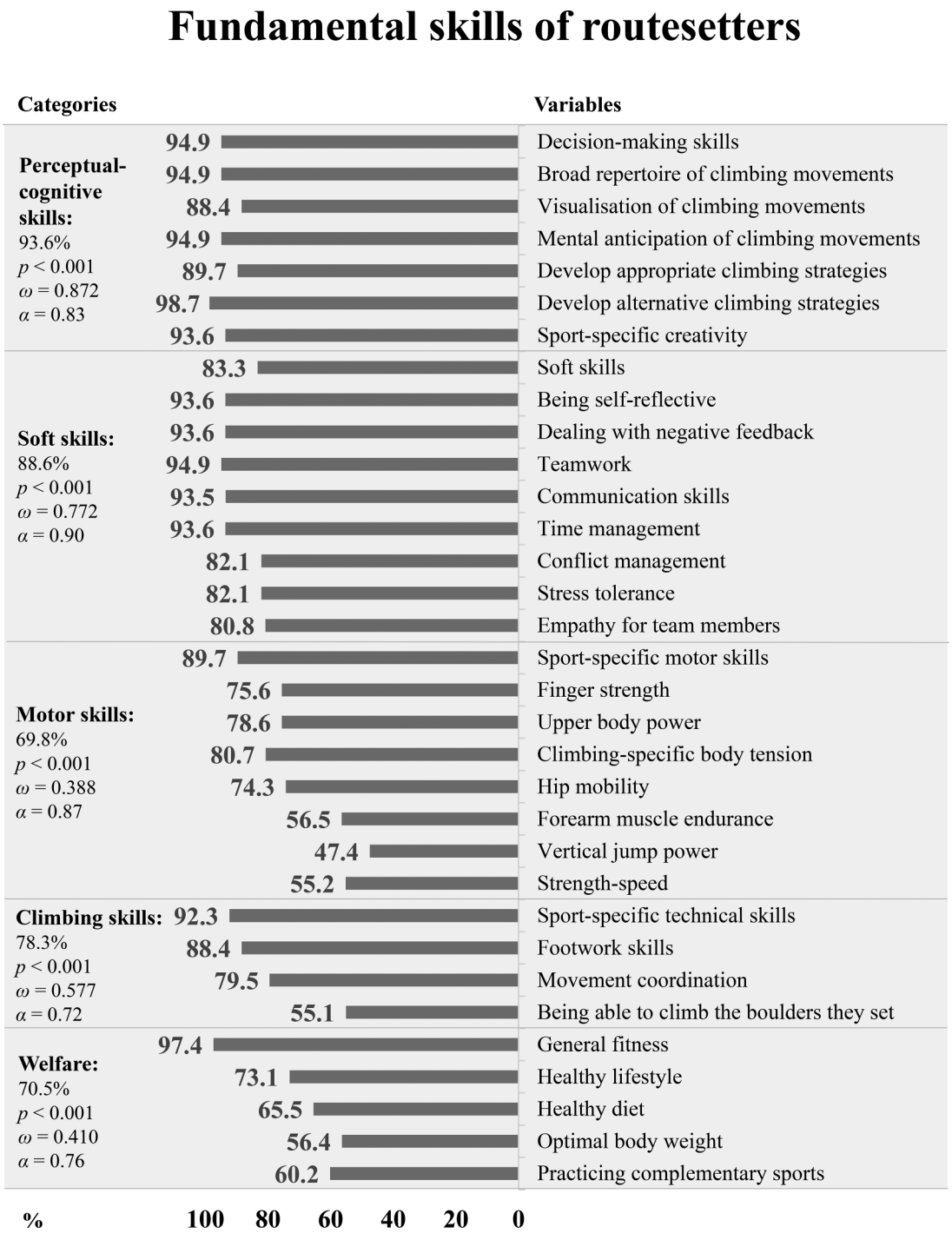

Figure 1. The percentages depicting the relevance of fundamental routesetter skills as perceived by the experts in our survey. For each category, the summarised *p*-values and ω-values, as well as Cronbach's α are indicated.

Results

Fundamental skills of routesetters

Perceptual-cognitive skills (category 1). The routesetting experts largely reported that domain-specific decision-making skills contributing to the appropriate interpretation of climbing movements (5.0 ± 0.9; $p < 0.001$; $\omega = 0.897$) are among the fundamental skills of routesetters. More precisely, they indicated that a broad repertoire of climbing movements (5.6 ± 0.8; $p < 0.001$; $\omega = 0.897$), the visualisation of climbing movements before physically attempting boulders (5.0 ± 1.0; $p < 0.001$; $\omega = 0.769$), and the mental anticipation of climbing movements based on previous climbing experience (5.2 ± 0.9; $p < 0.001$; $\omega = 0.897$) are

essential when designing boulders. Further perceptual–cognitive skills confirmed by the routesetters were the ability to develop appropriate climbing strategies to climb boulders (4.7 ± 1.2; $p < 0.001$; $\omega = 0.794$) and the ability to develop several alternative climbing strategies for one particular boulder (5.4 ± 0.8; $p < 0.001$; $\omega = 0.974$). Moreover, the experts also reported that sport-specific creativity (5.0 ± 1.0; $p < 0.001$; $\omega = 0.871$) is relevant for designing surprising and original climbing movements (see Figure 1).

Soft skills (category 2). Soft skills in general (4.6 ± 1.1; $p < 0.001$; $\omega = 0.666$), and being self-reflective (5.4 ± 0.9; $p < 0.001$; $\omega = 0.871$), dealing with negative feedback (5.1 ± 0.9; $p < 0.001$; $\omega = 0.871$), time management during routesetting (4.9 ± 0.9; $p < 0.001$; $\omega = 0.872$) and teamwork (5.1 ± 1.0; $p < 0.001$; $\omega = 0.897$) in particular were described as fundamental skills of routesetters. Additionally, communication within the team (5.0 ± 1.0; $p < 0.001$; $\omega = 0.872$), conflict management when setting as a team (4.7 ± 1.2; $p < 0.001$; $\omega = 0.641$), stress tolerance (4.5 ± 1.2; $p < 0.001$; $\omega = 0.641$) and empathy for team members (4.7 ± 1.3; $p < 0.001$; $\omega = 0.615$) were also reported as pivotal routesetter skills (see Figure 1).

Sport-specific motor skills (category 3). Experts largely stated that sport-specific motor skills (4.7 ± 0.9; $p < 0.001$; $\omega = 0.795$) are of relevance to routesetters. Specifically, they indicated that finger strength (4.1 ± 1.0; $p < 0.001$; $\omega = 0.513$), upper body power (4.2 ± 1.0; $p < 0.001$; $\omega = 0.513$), climbing-specific body tension (4.4 ± 1.1; $p < 0.001$; $\omega = 0.615$) and hip mobility (4.2 ± 1.0; $p < 0.001$; $\omega = 0.487$) are essential motor skills of routesetters. In addition, about half of the routesetters perceived forearm muscle endurance (3.7 ± 1.1; $p = 0.258$; $\omega = 0.128$), vertical jump power (3.4 ± 1.2; $p = 0.651$; $\omega = 0.051$) and strength-speed (3.6 ± 1.1; $p = 0.365$; $\omega = 0.103$) as relevant (see Figure 1).

Climbing skills (category 4). Experts mostly indicated (5.1 ± 0.9; $p < 0.001$; $\omega = 0.846$) that sport-specific technical skills are important when setting boulders. They particularly identified footwork skills (4.9 ± 1.0; $p < 0.001$; $\omega = 0.769$) and climbing movement coordination (4.5 ± 1.0; $p < 0.001$; $\omega = 0.600$) as important skills for routesetters. About half of the routesetters (3.6 ± 1.3; $p = 0.365$; $\omega = 0.106$) also reported that it is important to be able to climb the boulders they set (see Figure 1).

Welfare (category 5). The overall fitness level of routesetters (5.2 ± 0.8; $p < 0.001$; $\omega = 0.950$) has been identified as a relevant factor in routesetting. About two-thirds of the experts indicated that a healthy lifestyle (4.1 ± 1.2; $p < 0.001$; $\omega = 0.462$) and healthy diet (3.9 ± 1.3; $p < 0.001$; $\omega = 0.308$) are important. In this context (see Figure 1), approximately one out of two also stated that routesetters should aim for optimal body weight (3.6 ± 1.3; $p = 0.258$; $\omega = 0.128$) and practice complementary sports (3.8 ± 1.5; $p = 0.070$; $\omega = 0.205$).

Specific skills and strategies of routesetters

Safety and difficulty (category 6). As shown in Figure 2, the experts indicated that they take their own safety (93.6%; 5.4 ± 1.0; $p < 0.001$; $\omega = 0.872$) and the safety of climbers (5.6 ± 0.8; $p < 0.001$; $\omega = 0.949$) into account when setting boulders. Furthermore, they also confirmed that the ability to design boulders for target groups (5.3 ± 0.9; $p < 0.001$; $\omega = 0.897$) is essential. Moreover, experts broadly reported the importance of adapting the difficulty of boulders to target groups (5.4 ± 0.7; $p < 0.001$; $\omega = 0.974$) and accurately determining the difficult level of boulders (4.7 ± 0.9; $p < 0.001$; $\omega = 0.897$). About two-thirds (68.0%; 4.2 ± 1.4; $p = 0.002$; $\omega = 0.359$) reported using an official difficulty scale such as the Fb-scale (i.e. Fontainebleau) to grade boulders and preferring to rate the difficulty of boulders as a team (77.0%; 4.8 ± 1.3; $p < 0.001$; $\omega = 0.538$). Additionally, while most of them indicated knowing the RIC-scale (71.8%; 4.4 ± 2.0; $p = 0.631$; $\omega = 0.436$), only about one-third indicated using the RIC-scale to classify boulders (28.2%; 2.6 ± 1.6; $p < 0.001$; $\omega = 0.436$).

Climbing holds and wall features (category 7). About two out of three (61.5%; 4.0 ± 1.5; $p = 0.042$; $\omega = 0.231$) also indicated mixing different hold shapes (e.g. jugs with crimps) when setting boulders. However, only one out of three experts (28.2%; 2.8 ± 1.6; $p < 0.001$; $\omega = 0.436$) reported mixing climbing holds from different brands. Particularly the ability to adapt to the constraints of climbing gyms (5.2 ± 0.8; $p < 0.001$; $\omega = 0.949$), such as the number of available climbing holds and the wall characteristics, and best using features of the climbing walls (5.3 ± 0.8; $p < 0.001$; $\omega = 0.949$) were described as highly relevant when designing boulders. In this context, general manual skills (5.0 ± 1.0; $p < 0.001$; $\omega = 0.821$) have also been described to be relevant in routesetting. Moreover, the ability to design visually appealing boulders (4.5 ± 1.2; $p < 0.001$; $\omega = 0.641$) and to artistically design climbing walls (73.0%; 4.1 ± 1.2; $p < 0.001$; $\omega = 0.462$) were reported as essential (see Figure 2).

Climbing movement diversity and boulder styles (category 8). Experts reported that being able to design versatile climbing movements (5.5 ± 0.7; $p < 0.001$; $\omega = 0.949$) is an essential routesetter skill. Likewise, about two-thirds perceived the ability to design innovative climbing movements (62.9%; 4.0 ± 1.3; $p = 0.024$; $\omega = 0.256$) to be relevant. Experts mostly confirmed to commonly set different styles (5.3 ± 0.8; $p < 0.001$; $\omega = 0.974$) to provide climbing variety and even to combine different styles (e.g. slab start and dynamo top) to ensure climbing movement variation within a boulder (4.8 ± 1.1; $p < 0.001$; $\omega = 0.718$). While two out of three routesetters indicated to plan in advance what climbing movements they are going to set (69.2%; 4.1 ± 1.3; $p < 0.001$; $\omega = 0.385$), less than half of them reported to commonly use the ascending strategy to design boulders (44.9%; 3.5 ± 1.6; $p < 0.365$; $\omega = 0.103$);

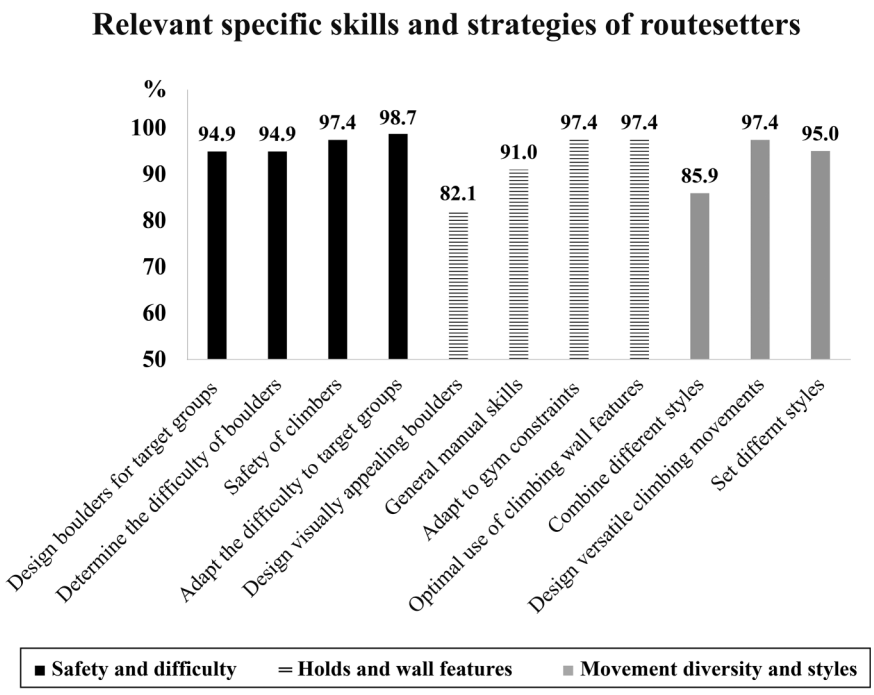

Figure 2. The percentages of the most relevant specific skills and strategies (category 6: safety attributes and difficulty of boulders; category 7: climbing holds and wall features; category 8: movement diversity and boulder styles) as perceived by the experts in our survey.

this is, when routesetters place the starting holds first and then set from the bottom up to the top hold. Similarly, half of the experts (53.8%; 3.6 ± 1.3; $p = 0.497$; $\omega = 0.080$) indicated that they commonly design the crux (i.e. most challenging sequence) of a boulder first and then proceed with the remaining movements. The minority of the experts reported to use the descending strategy when designing boulders (5.2%; 1.8 ± 1.0; $p < 0.001$; $\omega = 0.897$), in which they place the top hold first and then move down to the starting holds (see Figure 2).

Discussion

The present study profiled expert routesetters by identifying relevant key skills they possess and by examining specific strategies they use when designing and setting boulders in both the competitive and recreational contexts. Among fundamental skills experts identified, most relevant to routesetters were possessing a broad climbing movement repertoire, the ability to develop several climbing strategies for one boulder, forecasting the climbing movements, climbing-specific decision-making and creativity, self-reflection, teamwork, dealing with negative feedback, technical skills and general fitness. Moreover, findings showed that most relevant specific routesetter skills and strategies encompass the ability to design boulders that account for climbers' skill level and safety, adapting to the constraints of climbing gyms, and making optimal use of climbing wall features to design versatile climbing movements. Although the design of boulders depends on the context in which bouldering takes place (i.e. competitions, leisure activity), findings of this survey highlight relevant skills expert routesetters possess and specific strategies they use when designing both competitive and recreational boulders. Such skills and strategies play a critical role to keep the present success and ensure the future development of bouldering.

Fundamental skills of routesetters

Experts described a broad repertoire of climbing movements as essential for designing boulders. Domain-specific movement knowledge acquired through long-term deliberate practice[24] is a key climbing performance parameter.[25] It allows climbers to interpret climbing movements and develop appropriate climbing strategies[25] by assimilating environmental information (e.g. graspability of climbing holds) processed in working memory with movement patterns stored in long-term memory.[26,27] As such, the relevance of a broad climbing movement repertoire to routesetters is likely to be related to the fact that knowledge of climbing movements is compelling to designing boulders with versatile climbing movements and various styles for different target groups, all of which were rated as essential by the experts.

Besides a broad repertoire of climbing movements, experts identified decision-making skills for interpreting climbing movements appropriately, the ability to develop

suitable climbing strategies, and the ability to develop several alternative climbing strategies for a given boulder as essential. These findings, furthermore, underpin the paramount relevance of domain-specific perceptual and cognitive skills for routesetting and highlight that routesetters, similar to climbers, draw on their perceptual–cognitive abilities to link visual sensory input with existing knowledge to plan and design boulders. Such planning ahead of boulders, described by the experts as a relevant routesetter skill, is based on an extensive movement repertoire,[25] and requires thorough knowledge of the ability level and experience of the climbers for whom boulders are being designed. Additionally, perceptual–cognitive skills also allow routesetters to visualise climbing movements without physically testing boulders and to mentally forecast climbing movements based on previous experience, which are two abilities experts identified as fundamental.

Furthermore, expert routesetters highlighted the relevance of climbing-specific creativity; the ever-evolving skills of climbers require routesetters to constantly think out of the box, and explore new styles and design creative boulders that involve increasingly surprising and original climbing movements.[17,19] This striving for movement innovation is typical to modern competitive bouldering, where movement coordination,[17] creative motor solutions[12] and problem-solving skills[5] are increasingly critical.

In addition to perceptual–cognitive skills, experts also considered soft skills to be important for routesetters, with teamwork, time management, self-reflection and dealing with negative feedback among the most relevant. Particularly in the competitive framework, the relevance of these soft skills is mostly attributable to the fact that routesetting has evolved from an individual practice to a collaborative process in which routesetters work as a team to design boulders.[1,17] Research findings across different sport domains show that soft skills such as appropriate communication,[22] motivationally and supportive communication,[23] leadership[21] and care-seeking team cultures[28] can positively impact social cohesion, motivational engagement and collective efficacy. Similarly, based on our findings, soft skills such as appropriate conflict management, good communication skills and empathy for team members should also be cultivated in routesetting teams. This would particularly be of relevance in competition environments, which can be stressful and frustrating, as time pressure forces routesetters to quickly design various boulders that must comply with both regulations and expectations.[3]

Experts from our study confirmed that climbing-specific skills are essential when routesetting. These findings are likely to be related to the fact that being able to test the boulders routesetters design can be crucial for evaluating difficulty and movement complexity. This also explains why technical skills have, in particular, been described as relevant to routesetters; it allows routesetters to test the boulders and forecast properly given climbing movements. However, an interesting finding within this context was that only half of the participants considered it relevant to be able to climb the boulders they design. This finding could be associated with the paramount role of routesetters' perceptual–cognitive skills; it allows them, particularly when setting in the competitive framework, to visualise and plan climbing movements without actually performing all boulders they set.

Lastly, the relevance of welfare could be related to the fact that routesetting activity commonly takes place over an entire full day or even several consecutive days, which can be both physically and mentally extremely demanding. The findings that time management, stress tolerance and time pressure are crucial routesetter skills underpin this assumption. As such, a good general fitness, for instance, could be relevant to coping with physical stress and recovering rapidly. Moreover, it is worth noting that routesetters often must set numerous boulders within a short period of time. This implies that time constraints commonly hinder routesetters from testing the boulders they design, but also supports further why a good physical and mental health may be essential to perform at their best.

Specific skills and strategies of routesetters

Consistent with IFSC rules, which emphasise that climbers' health and safety are paramount, and in line with previous research on routesetting in sport climbing,[4] expert routesetters largely confirmed that accounting for their own safety and the safety of climbers is essential when setting boulders. Modern climbing facilities with increasing safety standards and the development of hold design, aimed at optimising the ergonomic shape of climbing holds, have contributed to reducing the risk of injuries.[17]

Experts described designing boulders for targeted groups and adapting boulder difficulty to such groups as essential routesetter skills. These findings may be related to the fact that routesetting occurs under different circumstances, ranging from physical education at school to world championships at the international arena. That is, routesetters must constantly account for the specific needs and abilities of climbers to ensure that their boulders are appropriately designed for each given target audience.[4]

Furthermore, findings revealed that adapting to constraints of climbing walls and optimally using climbing wall features are pivotal skills. These findings could be associated with the fact that climbing movements are inevitably inter-related to the characteristics of climbing walls. De Geus et al.[19] compared four climbing routes with the same difficulty level but with varying steepness and movement displacement. The authors observed highest peak and average heart rates in the route that included upward movement displacements, which was set on an overhanging wall. Similarly, characteristics of climbing walls also determine the boulder styles routesetters are likely to design. For

instance, overhanging walls (greater-than-vertical walls) typically involve *dynamo* boulders, whereas vertical walls (90-degree straight walls with no incline) encourage routesetters to set *slab* boulders.[3]

Expert routesetters also highlighted the importance of being able to design boulders with versatile climbing movements. Indeed, diversity of climbing movements is critical, whether it is for learning purposes or for the promotion of motivation and fun, which are essential for climbers to remain committed to the sport.[4] To ensure movement variation, a key strategy reported by the experts was to deliberately set different styles and combine different styles within a boulder. Within such a context, the arrangement and shape of climbing holds are relevant when designing versatile climbing movements, as they inherently impact upon movement characteristics. A somehow unexpected finding related to this aspect was that about two-thirds of our participants reported to knowing the existence of the RIC-scale, though less than one-third said they use it. While the RIC-scale is a helpful tool to ensure diversity of climbing movements, particularly in the competitive framework of routesetting, our findings are probably due to the fact that experienced routesetters can classify the movement characteristics of their boulders without using a scale.

Overall, the expert routesetters who participated in our survey identified a series of fundamental skills they possess and specific routesetter skill and strategies they use to design and set both competitive and recreational boulders. Regardless of the routesetting context in which bouldering takes place (e.g. competitions, leisure activity), such skills and strategies are critical for routesetters in general to ensure climbers' welfare, provide movement versatility and adapt the climbing movements to the climbers' levels. However, considering that these skills and strategies may differ between routesetting in the competitive and recreational contexts, further research is needed to explore these fundamental skills and strategies with regard to routesetting in the Olympic discipline of bouldering.

Conclusion

Routesetting in bouldering requires a variety of domain-specific skills and strategies. Alongside fundamental perceptual–cognitive skills, soft skills, motor skills, climbing skills and welfare considerations, most relevant specific routesetter skills and strategies encompass the ability to design boulders that account for climbers' skill level and safety, adapt to the constraints of climbing gyms, make optimal use of climbing wall features and design visually appealing boulders with versatile climbing movements and styles.

Data availability statement

The data that support the findings of this study are openly available: https://doi.org/10.7910/DVN/BG20I0

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs

Julian Henz https://orcid.org/0000-0001-7966-0092
Jerry Prosper Medernach https://orcid.org/0000-0003-1873-2704

References

1. Hatch T and Leonardon F. Rules 2023. *International Federation of Sport Climbing*, https://www.ifsc-climbing.org/index.php/world-competition/rules (2023, assessed 12 October 2023).
2. Morenas J, Del Campo VL, López-García S, et al. Influence of on-sight and flash climbing styles on advanced climbers' route completion for bouldering. *Int J Environ Res Public Health* 2021; 18: 1–12.
3. Augste C, Sponar P and Winkler M. Athletes' performance in different boulder types at international bouldering competitions. *Int J Perform Anal Sport* 2021; 21: 409–420.
4. Phillips C, Becker L and Bradley E. Strange beta: An assistance system for indoor rock climbing route setting. *Chaos* 2012; 22: 1–30.
5. Medernach JP and Memmert D. Effects of decision-making on indoor bouldering performances: a multi-experimental study approach. *PLoS One* 2021; 16: 1–26.
6. Winkler M, Künzell S and Augste C. The load structure in international competitive climbing. *Front Sports Act Living* 2022; 4: 1–10.
7. Saul D, Steinmetz G, Lehmann W, et al. Determinants for success in climbing: a systematic review. *J Exerc Sci Fit* 2019; 17: 91–100.
8. Fryer S, Dickson T, Draper N, et al. A psychophysiological comparison of on-sight lead and top rope ascents in advanced rock climbers. *Scand J Med Sci Sports* 2013; 23: 645–650.
9. Baláš J, Pecha O, Martin AJ, et al. Hand-arm strength and endurance as predictors of climbing performance. *Eur J Sport Sci* 2012; 12: 16–25.
10. Seifert L, Cordier R, Orth D, et al. Role of route previewing strategies on climbing fluency and exploratory movements. *PLoS One* 2017; 12: 1–22.
11. Sanchez X, Torregrossa M, Woodman T, et al. Identification of parameters that predict sport climbing performance. *Front Psychol* 2019; 10: 1–10.
12. Künzell S, Thomiczek J, Winkler M, et al. Finding new creative solutions is a key component in world-class competitive bouldering. *Ger J Exerc Sport Res* 2021; 51: 112–115.
13. Boudreau P, Houge Mackenzie S and Hodge K. Optimal psychological states in advanced climbers: Antecedents, characteristics, and consequences of flow and clutch states. *Psychol Sport Exerc* 2022; 60. https://doi.org/10.1016/j.psychsport.2022.102155

14. Aşçi FH, Demirhan G, Koca C, et al. Precompetitive anxiety and affective state of climbers in indoor climbing competition. *Percept Mot Skills* 2006; 102: 395–404.
15. Bailey A, Hughes A, Bullock K, et al. A climber's mentality: EEG analysis of climbers in action. *J Outdoor Recreat Ed* 2019; 11: 53–69.
16. Winkler M, Künzell S and Augste C. Competitive performance predictors in speed climbing, bouldering, and lead climbing. *J Sports Sci* 2023; 41: 736–746.
17. Neumann U. The evolution of modern route setting. In: M Polig and M Hilber (eds) *Routesetter*. Bressanone: Vertical-Life s.r.l, 2019, pp.34–39.
18. Tamerler J. Indoor rock climbing: The nuts and bolts of routesetting copyright protection post-star athletica. *Jeffrey S Moorad Sports L J* 2021; 28: 1–49.
19. De Geus B, Villanueva O'Driscoll S and Meeusen R. Influence of climbing style on physiological responses during indoor rock climbing on routes with the same difficulty. *Eur J Appl Physiol* 2006; 98: 489–496.
20. Draper N, Giles D, Schöffl V, et al. Comparative grading scales, statistical analyses, climber descriptors and ability grouping: international rock climbing research association position statement. *Sports Technol* 2016; 8: 88–94.
21. Cotterill ST and Fransen K. Athlete leadership in sport teams: current understanding and future directions. *Int Rev Sport Exerc Psychol* 2016; 9: 116–133.
22. Davis L, Jowett S and Tafvelin S. Communication strategies: The fuel for quality coach-athlete relationships and athlete satisfaction. *Front Psychol* 2019; 10. https://doi.org/10.3389/fpsyg.2019.02156
23. Ntoumanis N, Quested E and Reeve J. Need-supportive communication. Implications for motivation in sport, exercise, and physical activity. In: B Jackson, J Dimmock and J Compton (eds) *Persuasion and communication in sport, exercise, and physical activity*. Abingdon: Routledge, 2017, pp.155–169.
24. Fleming RK and Hörst EJ. Behavior analysis and sports climbing. *J Behav Health Med* 2010; 1: 143–154.
25. Medernach JP, Henz J and Memmert D. Mechanisms underlying superior memory of skilled climbers in indoor bouldering. *J Sports Sci* 2024; 41: 1837–1844.
26. Cowell RA, Barense MD and Sadil PS. A roadmap for understanding memory: decomposing cognitive processes into operations and representations. *eNeuro* 2019; 6: 1–19.
27. Roca A and Williams AM. Expertise and the interaction between different perceptual-cognitive skills: Implications for testing and training. *Front Psychol* 2016; 7: 1–4.
28. Bissett JE, Kroshus E and Hebard S. Determining the role of sport coaches in promoting athlete mental health: A narrative review and Delphi approach. *BMJ Open Sport Exerc Med* 2020; 6