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Introduction

Breivik (1999, p. 10) defined high-risk sports as, "all sports where you have to reckon with the possibility of serious injury or death as an inherent part of the activity". High-risk sports, such as freeride skiing, paragliding and mountaineering are no longer fringe activities with few participants, but are increasingly popular and have become a socially acceptable form of risk-taking (Pain & Pain, 2005; Turner, McClure, & Pirozzo, 2004).

Risk-taking research has long been dominated by Zuckerman's Sensation Seeking Theory (Zuckerman, 2008). The construct of Sensation Seeking was discussed as the major motive for starting and maintaining health-risk behaviors such as drug taking, gambling and also participation in high-risk sports. Indeed, Zuckerman's sensation seeking questionnaire, the Sensation Seeking Scale V (SSS-V; Zuckerman 1994), has been termed "synonymous" (p. 414) with risk-taking research (Llewellyn & Sanchez, 2008). However, measuring motivation to engage in high-risk sports through the SSS-V is biased. Many items of the Thrill and Adventure Seeking subscale of the SSS-V relate to the willingness of the participants to engage in high-risk sports (e.g., mountain climbing); however, these items are somewhat tautological when assessing sensation seeking within a population of high-risk sports participants (Llewellyn & Sanchez, 2008).

Suggesting that sensation seeking is the single panoptic explanation for voluntary engagement in sports as diverse as Himalayan mountaineering (e.g., extended duration, long periods of boredom, physically painful) and skydiving (e.g., very limited duration, characterized by thrilling enjoyable sensations) seems overly simplistic and several studies have shown that the motives for participation in high-risk sport are more varied than this (Barlow et al., 2015; Barlow, Woodman, & Hardy, 2013; Castanier, Le Scanff, & Woodman, 2010; Castanier, Le Scanff, & Woodman, 2011; Frühauf, Hardy, Pfoestl, Hoellen, & Kopp, 2017; Kerr & Houge Mackenzie, 2012; Lafollie & Le Scanff, 2007; Woodman et al., 2013; Woodman, Hardy, Barlow, & Le Scanff, 2010; Woodman, Huggins, Le Scanff, & Cazenave, 2009). A number of qualitative studies have uncovered additional and alternative motives for participation in high-risk sports (e.g., emotion regulation, agency, challenge, nature) (Brymer, 2010; Brymer & Gray, 2010; Frühauf et al., 2017; Kerr & Houge Mackenzie, 2012; Willig, 2008; Woodman et al., 2010). In light of these developments in understanding the motivations for participation in high-risk sports, a number of quantitative tools have been developed.

Barlow et al. (2013) established the Sensation Seeking, Emotion Regulation and Agency Scale (SEAS), a series of inventories that measure the following: the need for sensation, difficulty with emotion regulation, and lack of agency between bouts of participation in high-risk sports; the experience of sensation, emotion regulation, and agency while participating; and the transfer of sensation, emotion regulation, and agency following participation. This was based on research showing that participants in prolonged high-risk activities have difficulty with emotion regulation and a diminished sense of agency in aspects of their life and thus might participate in those high-risk sport activities to experience agency and become aware of their emotions (Woodman et al., 2010). Barlow et al. (2013) developed the SEAS using a variety of participants who took part in both high-risk sports (e.g., mountaineering and skydiving) and low-risk sports (e.g., basketball and hockey), in doing so they found that some activities might be motivated by the sensations of the activity (e.g., skydiving) and others might be motivated by the emotion regulation and agency transfers (e.g., mountaineering).

Understanding the motives for participation in high-risk sports allows researchers to better comprehend the potential benefits and risks to participants. Nevertheless, the objective risk of the activity is undeniable, which is underlined by the higher rates of both acci-

Table 1 Bayesian structural equation modelling (BSEM) fit and convergence

Scale	No. of free parameters	DIC	PP*p*	Difference between observed and replicated χ^2 95% credibility interval: Lower 2.5%	Upper 2.5%	Iterations PSR >1.1	Final PSR
G-SEAS Between	164	20,934.814	0.506	–44.003	42.693	45,800	1.016
G-SEAS While	164	24,762.467	0.507	–43.554	42.348	74,100	1.039
G-SEAS After 3-factor	164	19,096.132	0.512	–44.497	42.766	33,500	1.012
G-SEAS After 2-factor	148	19,097.742	0.517	–44.149	42.083	44,700	1.039
G-ACCSI	40	10,168.852	0.490	–20.447	21.182	67,800	1.009
G-RTI	50	11,324.093	0.514	–23.794	23.269	68,200	1.028

DIC Deviance Information Criteria, *PPp* posterior predictive *p*, *PSR* potential scale reduction factor, *G-SEAS* German Sensation Seeking, Emotion Regulation and Agency Scale, *G-ACCSI* German Accidents and Close Calls in Sports Inventory, *G-RTI* German Risk-Taking Inventory

dents and close calls[1] in high-risk sports than in low-risk sports (Barlow et al., 2015; Gosteli et al., 2016). To contribute towards more safety in high-risk sports two further aspects have to be taken into account, namely objective risks and participants' behavior.

Objective risks (e.g., environmental hazards such as avalanches) must be accepted as an inherent aspect of participation in high-risk sport, but participants are not risk-takers *per se* since they are able to influence their risk exposure by adapting their behavior (Gosteli et al., 2016; Leiter & Rheinberger, 2016; Llewellyn & Sanchez, 2008). Whereas objective risks cannot be modified, there seems to be an orthogonal nature of behavior in participants which consists of deliberate risk-taking and precautionary behavior (Woodman et al., 2013). To contribute to the understanding of these behaviors, the Risk-Taking Inventory (RTI) was developed to measure precautionary behavior (PB) and deliberate risk-taking (DRT) in high-risk sport participants (Woodman et al., 2013). Recent research suggests that behavior in high-risk sport, namely in freeriding, changes based on individuals' experiences of accidents and close calls (Frühauf et al., 2017). Thus, it is important to quantify accidents and close calls and relate them to participants' behaviors. This can be done by using the Accidents and Close Calls in Sports Inventory (ACCSI; Barlow et al., 2015). Research showed that accidents and close calls were positively correlated to DRT and negatively to PB (Barlow et al., 2015).

At present, SEAS, RTI, and ACCSI are available only in the English language and the scales were validated with English-speaking participants. However, there are differences in the amount of leisure time physical activity across European countries (Martínez-González et al., 2001) and there is also evidence for cross-cultural differences in risk-taking (Mata, Josef, & Hertwig, 2016) regarding risk behaviors like gambling or speed driving (Molinaro et al., 2014; Wallén Warner, Ozkan, & Lajunen, 2009).

Furthermore, there is a dearth of validated measures for carrying out research in non-English-speaking high-risk sport populations. When considering that "The Alps comprise the largest and most popular sports region in Europe" (p. 1) and that many alpine sports are classified as high-risk sports (e.g., ski touring, mountaineering, mountain biking, rock and ice climbing and paragliding; Burtscher, 2008), it becomes clear that there is a need for validated measure for conducting research in non-English-speaking high-risk sport populations. Austria is just one German-speaking alpine country with almost one third of the 180,000 km^2 of mountainous area in the Alps (Burtscher, 2008). Thus, with the aim of taking the first step towards filling the lacuna highlighted above the aim of the present research was to validate German language versions of the SEAS, RTI, and ACCSI.

Method

Procedure

Following institutional approval by the Board for Ethical Questions in accordance with the Declaration of Helsinki, we collected the data using a web-based questionnaire in a cross-sectional design. We recruited participants from a number of different high-risk sports via emails to students and employees of the University of the first author and local sports clubs (e.g., paragliding association). All participants completed the survey online. Participants not finishing the survey were excluded from analyses.

Participants

The final number of participants was 719 (25% female), with the highest numbers of individuals performing various disciplines in paragliding (59%). Further, the sample consisted of freeride skiers (14%), mountain trail runners[2] (16%), freestyle skiers/snowboarders (7%), as well as mountaineering athletes (4%). The participants had a mean age of 35.4 (±11.6) years and reported an average of 7.3 (±6.1) years of experience. Age and experience varied between sport activities, with the youngest age and lowest years of experience in freestyle skiing and snowboarding (age: 23.0 ± 3.8 years; years of experience: 6.0 ± 3.6 years) and the oldest age and most years of experience in paragliding (age: 38.9 ± 11.4 years;

[1] Close calls are defined as "incidents that come very close to resulting in a negative outcome" (Woodman et al., 2013, p. 480)

[2] Mountain trail running as performed in the Alps is considered a high-risk sport since there is a risk of death and life-threatening accidents due to the exposure and steepness of the trails and/or sudden weather changes which occur in the mountains.

years of experience: 7.9 ± 6.5 years). Female participation ranged from 19% in freestyle skiing/snowboarding to 32% in mountain trail running.

Scales

Sensation Seeking, Emotion Regulation and Agency Scale (SEAS)

The SEAS (Barlow et al., 2013) comprises three separate inventories which measure three different factors asking about three different times namely *Between* participation, *While* participating, and *After* participation. The *Between* participation inventory evaluates the time when not participating for a significant amount of time and measures need for sensation, difficulty with emotion regulation and lack of agency. The *While* inventory evaluates the experience of sensation seeking, emotion regulation and agency asking about the time while participating. The *After* inventory measures the transfer of sensation, emotion regulation, and agency asking about the time following participation. Each inventory contains 18 items with a seven-point Likert scale response mode ranging from one (completely disagree) to seven (completely agree).

Barlow et al. (2013) found evidence to support a three-factor structure for the *Between* and *While* inventories; however, they found that a two-factor model was a better fit to the data for the *After* inventory, with Agency and Emotion Regulation being combined into a single factor (i.e., agentic emotion regulation). Cronbach's alpha (α) displayed good internal consistency for each factor: *Between* participation inventory ($\alpha \geq 0.84$), *While* participating inventory ($\alpha \geq 0.70$), and *After* participation inventory ($\alpha \geq 0.89$). The SEAS factors correlated with established measures of sensation seeking, emotion regulation and agency (Barlow et al., 2013).

Risk-Taking Inventory (RTI)

The RTI (Woodman et al., 2013) measures risk-taking in high-risk sports across two orthogonal factors, deliberate risk-taking (DRT, three items) and precautionary behaviors (PB, four items) on a seven item five-point Likert-scale

Abstract · Zusammenfassung

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Abstract

The aim of the present research was to validate German language versions of three inventories in high-risk sports to facilitate future research in the significant population of German speaking high-risk sports participants. We translated the Sensation Seeking, Emotion Regulation and Agency Scale (SEAS), the Risk-Taking Inventory and the Accidents and Close Calls in Sport Inventory into German, then tested the hypothesized factor structures with 719 high-risk sport participants from the European Alps using Bayesian structural equation modelling (BSEM). The final models were all good fits to the data, had good internal consistency and displayed adequate discriminant validity. All inventories displayed the same factor structure as in the English inventories bar the G-SEAS *After* inventory in which a three-factor model fitted better than a two-factor model. Possible reasons for this difference include differences in the sample population, translation bias, or cross-cultural differences; however it seems likely that the nuanced approach of BSEM allowed this study to disentangle emotion regulation transfer from agency transfer after participating in high-risk sport where previous attempts using other methods have failed to. This will allow future research in high-risk sport to be conducted beyond English speaking populations and more significantly, facilitate the investigation of differences between the transfer effects of agency and emotion regulation.

Keywords

Risk-taking · Sensation seeking · Emotion regulation · Agency · Bayesian statistics

Strukturelle Validierung dreier deutscher Versionen von Verhaltens- und Motivationsskalen für Hochrisikosportarten

Zusammenfassung

Das Ziel der vorliegenden Untersuchung war es drei Versionen von Erhebungsinstrumenten im Hochrisikosport für die Verwendung bei deutschsprechenden Populationen zu validieren. Die Sensation Seeking, Emotion Regulation and Agency Scale (SEAS), das Risk-Taking Inventory und das Accidents and Close Calls in Sport Inventory wurden in die deutsche Sprache übersetzt. Die vermutete Faktorenstruktur wurde mit Strukturgleichungsmodellen der Bayesschen Statistik (BSEM) an 719 Hochrisikosportlern aus den europäischen Alpen getestet. Die finalen Modelle zeigten gute Werte für die Anpassungsgüte und für die interne Konsistenz sowie adäquate Werte für die Diskriminanzvalidität.Bis auf die G-SEAS *Nach der Sportausübung* wiesen alle Skalen die gleiche Faktorenstruktur wie die englischen Skalen auf. Im Gegensatz zu dem englischen Zwei-Faktoren-Modell in der SEAS *Nach der Sportausübung* zeigte sich ein Drei-Faktoren-Modell in der deutschen Skala. Mögliche Gründe für diese Diskrepanz könnten Unterschiede in der Stichprobe, Übersetzungsbias oder interkulturelle Unterschiede sein. Allerdings erscheint es wahrscheinlich, dass der differenzierte Zugang der BSEM Berechnung dieser Studie erlaubte, den Transfer von Emotionsregulierung und wahrgenommener Kontrolle über die eigenen Handlungen (Agency) in der G-SEAS Nach der Sportausübung zu lösen. Angesichts der Validierungskennwerte können die Skalen für künftige Forschung im Hochrisikosport auch im deutschen Sprachraum empfohlen werden. Die drei-faktorielle Struktur der G-SEAS Nach der Sportausübung ermöglicht es zudem, etwaige Unterschiede zwischen den Transfereffekten von Agency und Emotionsregulierung herauszufiltern.

Schlüsselwörter

Risikoverhalten · Sensation Seeking · Emotionsregulierung · Agency · Bayessche Statistik

Table 2 German Sensation Seeking, Emotion Regulation and Agency Scale (G-SEAS) *Between* items and standardized factor loadings with 95% credibility intervals (CI) in brackets

Original item (Barlow et al., 2013)	German translation	Sensation seeking	Emotion regulation	Agency
1. I want to get an adrenaline rush	Ich möchte einen Adrenalinkick bekommen	**0.86 [0.73, 0.99]**	0.04 [–0.11, 0.19]	–0.02 [–0.17, 0.13]
2. I look forward to getting a physical thrill from participating	Ich erhoffe mir einen körperlich wahrnehmbaren Nervenkitzel beim Paragliding	**0.90 [0.77, 1.02]**	–0.03 [–0.19, 0.12]	0.01 [–0.15, 0.14]
3. I look forward to the "rush" I hope to experience while participating	Ich freue mich auf den Kick, den ich während der Ausübung zu erleben hoffe	**0.85 [0.69, 1.00]**	–0.03 [–0.19, 0.12]	–0.01 [–0.17, 0.15]
6. I feel the need to do something intensely stimulating	Ich habe das Verlangen, etwas besonders Aufregendes zu tun	**0.76 [0.57, 0.92]**	0.02 [–0.15, 0.19]	0.03 [–0.13, 0.18]
7. The emotional elements of my life are difficult to deal with	Es ist schwer mit emotionalen Anteilen von meinem Leben umzugehen	0.02 [–0.11, 0.15]	**0.85 [0.67, 1.04]**	0.03 [–0.15, 0.18]
8. I am emotional (e.g., anxious, angry) without understanding why	Ich werde emotional (z.B. ängstlich, wütend), ohne zu wissen warum	–0.03 [–0.16, 0.10]	**0.92 [0.75, 1.10]**	–0.03 [–0.20, 0.13]
9. I struggle to deal with stressful situations in my life	Ich habe Schwierigkeiten mit Stresssituationen in meinem Leben umzugehen	–0.02 [–0.14, 0.10]	**0.86 [0.69, 1.04]**	0.06 [–0.12, 0.21]
10. I can't work out which emotion I am experiencing	Ich kann nicht eindeutig zuordnen, welche Emotion ich gerade erlebe	0.01 [0.14, 0.15]	**0.78 [0.57, 0.99]**	0.02 [–0.17, 0.19]
11. I find that emotional situations in my life stress me out	Mich belasten emotionale Situationen in meinem Leben	0.01 [–0.12, 0.01]	**0.89 [0.71, 1.08]**	–0.03 [–0.21, 0.14]
13. I am prevented from achieving my goals in life	Ich werde am Erreichen meiner Lebensziele gehindert	0.04 [–0.10, 0.17]	0.02 [–0.17, 0.21]	**0.78 [0.59, 0.98]**
14. I feel like a passive observer of my life rather than a major "actor"	Ich fühle mich eher als passiver Beobachter meines Lebens und weniger als aktiv steuernde Person	–0.01 [–0.14, 0.11]	0.02 [–0.16, 0.19]	**0.86 [0.68, 1.03]**
16. I feel like my life "belongs" to other people	Ich fühle mich, als ob andere über mein Leben bestimmen	–0.01 [–0.13, 0.12]	–0.06 [–0.23, 0.10]	**0.92 [0.76, 1.09]**
17. I feel trapped	Ich fühle mich gefangen	–0.07 [–0.21, 0.07]	–0.03 [–0.21, 0.15]	**0.87 [0.67, 1.06]**
18. I have little belief in my own ability to influence some important aspects of my life	Ich glaube nicht daran, dass ich die Fähigkeit habe, wichtige Aspekte meines Lebens zu beeinflussen	0.05 [–0.08, 0.18]	0.08 [–0.10, 0.25]	**0.77 [0.61, 0.96]**

Loadings and 95% CIs on intended factors in bold text

ranging from one (*never*) to five (*always*). Internal consistency was evidenced by composite reliabilities of 0.64–0.78 for DRT and 0.64–0.71 for PB across three studies (Woodman et al., 2013).

Accidents and Close Calls in Sport Inventory (ACCSI)

The ACCSI (Barlow et al., 2015) is a six-item, two-factor inventory asking about experienced accidents (three items) and close calls (three items) on a seven-point Likert scale from one (*never*) to seven (*always*). A good model fit was confirmed in varying samples (Barlow et al., 2015). Moderate correlations between DRT and Accidents (r = 0.31–0.54) and Close Calls (r = 0.52–0.64) were shown. PB showed weaker, negative correlations with Accidents (r = –0.02 to –0.33) and Close Calls (r = –0.10 to –0.34).

German scale development

We translated the items following the guidelines of Guillemin, Bombardier, and Beaton (1993). The items were translated into German by a group of Sports Science Masters students, who were all fluent in German, and they were asked to note any remarks and questions while translating. The group met to discuss items and phrases until full consent was reached. In the next step translated and original items were sent to three experts from the field of health psychology and sport science who were equally fluent in both English and German language. They were asked if the German items were an accurate translation of the original English items, when they identified problematic items we modified them and the process was repeated until the experts agreed that all of the German items accurately represented the meaning of the original English ones.

Statistical analyses

We tested the hypothesized factor structure using Bayesian structural equation modelling (BSEM) in Mplus 7 (Muthén & Muthén, 2012), estimating BSEMs with weakly informative priors for approximate zero cross-loadings and residual correlations, as recommended by Muthén and Asparouhov (2012), for each inventory. Each BSEM was estimated using the Markov chain Monte Carlo (MCMC) simulation procedure, using the Gibbs sampler over 200,000 iterations across two MCMC chains in order to assess model convergence and stability of estimates.

Model convergence can be assessed in a number of ways (Kaplan & Depaoli, 2012). In this study, we used the Gelman-Rubin convergence diagnostic (potential scale reduction factor; PSR) and Kol-

Table 3 German Sensation Seeking, Emotion Regulation and Agency Scale (G-SEAS) *While* items and standardized factor loadings with 95% credibility intervals (CI) in brackets

Original item (Barlow et al., 2013)	German translation	Sensation seeking	Emotion regulation	Agency
1. I enjoy getting a physical thrill	Mir gefällt es, einen körperlich wahrnehmbaren Nervenkitzel zu bekommen	**0.79 [0.56, 0.96]**	–0.06 [–0.22, 0.10]	0.04 [–0.12, 0.20]
2. I experience intense excitement	Ich bin sehr aufgeregt	**0.72 [0.42, 0.94]**	0.03 [–015, 0.21]	–0.06 [–0.23, 0.11]
5. I get a rush of chemical around my body that feels great	Ich bekomme durch die Ausschüttung von körpereigenen Substanzen einen Kick, der sich großartig anfühlt	**0.82 [0.62, 0.99]**	0.01 [–0.16, 0.16]	–0.02 [–0.17, 0.13]
6. I experience physical sensations that feel great	Ich erlebe körperliche Empfindungen, die sich großartig anfühlen	**0.65 [0.38, 0.91]**	0.06 [–0.12, 0.23]	0.07 [–0.10, 0.23]
8. I have to deal with stressful situations	Ich muss mit Stresssituationen umgehen können	–0.11 [–0.28, 0.08]	**0.71 [0.40, 0.94]**	0.03 [–0.16, 0.20]
10. I prove to myself that I can deal with stressful situations	Ich beweise mir selbst, dass ich mit Stresssituationen umgehen kann	0.05 [–0.13, 0.21]	**0.77 [0.57, 0.97]**	0.04 [–0.13, 0.19]
11. I have to deal with intense emotions	Ich muss ich mit intensiven Gefühlen umgehen	0.03 [–0.14, 0.18]	**0.84 [0.66, 1.01]**	–0.03 [–0.18, 0.12]
12. The emotions I experience are more intense that in other areas of my life	Die Gefühle die ich erlebe sind intensiver als in anderen Bereichen meines Lebens	0.02 [–0.16, 0.19]	**0.73 [0.49, 0.96]**	0.00 [–0.17, 0.17]
13. If a difficult situation arises I feel able to deal with it	Ich fühle ich mich in der Lage eine schwierige Situation zu meistern, wenn diese auftritt	0.04 [–0.12, 0.21]	0.06 [–0.12, 0.23]	**0.59 [0.32, 0.82]**
14. I am free from the constraints imposed on me in the rest of my life	Ich bin frei von Einschränkungen meines täglichen Lebens	0.01 [–0.16, 0.18]	0.04 [–0.15, 0.22]	**0.61 [0.36, 0.86]**
15. I choose how far to push when I am scared	Ich entscheide, wie weit ich in Angstsituationen gehe	–0.00 [–0.16, 0.17]	0.02 [–0.16, 0.18]	**0.71 [0.48, 0.92]**
16. I am in charge	Ich habe das Sagen	0.01 [–0.16, 0.17]	–0.04 [–0.21, 0.13]	**0.74 [0.50, 0.92]**
17. My actions and decisions prevent undesired outcomes from happening	Meine Handlungen und Entscheidungen verhindern das Eintreten unerwünschter Ereignisse	–0.05 [–0.21, 0.12]	–0.02 [–0.20, 0.15]	**0.72 [0.50, 0.91]**
18. No one can force me to do something I don't want to do	Niemand kann mich zwingen etwas zu tun, was ich nicht will	0.00 [–0.17, 0.17]	–0.00 [–0.17, 0.17]	**0.65 [0.37, 0.86]**

Loadings and 95% CIs on intended factors in bold text

mogorov-Smirnov (K-S) tests to assess model convergence in addition to visual inspection of all parameter trace plots. Model convergence is evident when the PSR value approaches one following the warm-up period (i.e., the first half of the iterations) (Gelman et al., 2014), when K-S tests show no significant differences between the estimates of parameter distribution across the chains, and when parameter values in each MCMC chain mix well (i.e., have stable means and variances (van de Schoot & Depaoli Sarah, 2014)).

We assessed model fit by examining: factor loadings, the posterior predictive *p* (PP*p*) value and the results of likelihood χ^2 tests, which examine differences between the model generated and the observed data. Excellent model fit is indicated by PP*p* values of approximately 0.50 and with a symmetric 95% credibility intervals (CI) centered around zero (Muthén & Asparouhov, 2012). We assessed internal consistency using the composite reliability coefficient (Fornell & Larcker, 1981) and discriminant validity using the latent variable correlations obtained from the BSEMs.

Where good model fit or convergence was not reached we re-examined the items in each scale to identify which items were problematic. To improve model fits, we removed items from each inventory; items were considered for removal based on the following criteria: having low factor loadings (< 0.6); theoretical (ir)relevance; having substantive cross-loadings or correlated residual variances (> ± 0.2); parameters with significant K-S tests; the highest PSR; or trace plots which showed poor mixing of the MCMC chains. Once identified, we removed these items and re-estimated the BSEM. We repeated this process until the final model for each inventory was both statistically and theoretically sound; it was important that item removal could be justified both statistically and theoretically to avoid making modifications based on sample specific, chance characteristics of the data, which then may not represent the relationships among variables in the wider population (Biddle, Markland, Gilbourne, Chatzisarantis, & Sparkes, 2001).

Given that Barlow et al. (2013) found a two-factor structure to be most appropriate for the SEAS *After* inventory, we analyzed our data with two- and three-factor models in order to see if the translated version confirmed these initial findings. In addition to the criteria mentioned above, we used the Deviance Information Criteria (DIC) to compare the two- and three-factor G-SEAS *After* inventory as recommended by Asparouhov, Muthén, and Morin (2015).

Once the final models were established we performed a sensitivity analysis as the

Table 4 German Sensation Seeking, Emotion Regulation and Agency Scale (G-SEAS) 3-factor model *After* items and standardized factor loadings with 95% credibility intervals (CI) in brackets

Original item (Barlow et al., 2013)	German translation	Sensation seeking	Emotion regulation	Agency
1. I enjoy the feeling of adrenaline flowing around my body	Ich genieße es, wenn Adrenalin durch meinen Körper strömt	**0.90 [0.77, 1.05]**	–0.03 [–0.19, 0.13]	–0.01 [–0.17, 0.13]
2. I feel like I have satisfied my immediate need for thrill	Ich habe das Gefühl, dass ich mein Bedürfnis nach einem Nervenkitzel gestillt habe	**0.88 [0.72, 1.03]**	–0.02 [–0.18, 0.14]	–0.02 [–0.18, 0.13]
3. I am often buzzing from the adrenaline	Ich bin oft vom Adrenalin berauscht	**0.83 [0.71, 1.00]**	0.01 [–0.15, 0.17]	0.00 [–0.16, 0.15]
5. I enjoy the rush of chemicals still flowing round my body	Ich genieße den Kick der ausgeschütteten Substanzen, die immer noch meinen Körper durchfluten	**0.87 [0.75, 1.01]**	0.02 [–0.13, 0.17]	0.01 [–0.14, 0.15]
6. I look back and think how much I enjoyed the rush	Ich blicke zurück und erinnere mich daran, wie sehr ich den Kick genossen habe	**0.81 [0.65, 0.96]**	0.02 [–0.15, 0.18]	0.03 [–0.13, 0.18]
9. I find intense emotions easier to deal with	Ich kann mit intensiven Gefühlen besser umgehen	0.02 [–0.12, 0.15]	**0.88 [0.70, 1.08]**	0.02 [–0.16, 0.18]
10. I find it easier to deal with stressful situations in my life	Ich kann mit Stresssituationen im Alltag besser umgehen	–0.05 [–0.19, 0.09]	**0.90 [0.71, 1.11]**	0.02 [–0.17, 0.20]
11. I feel better for having experienced my emotions	Ich fühle mich besser, nachdem ich meine Emotionen in Erfahrung gebracht habe	0.09 [–0.06, 0.22]	**0.86 [0.66, 1.08]**	–0.04 [–0.22, 0.14]
12. I feel better able to deal with aspects of my life that would normally make me feel emotional	Ich kann besser mit Situationen umgehen, welche mich üblicherweise emotional berühren würden	–0.03 [–0.17, 0.10]	**0.89 [0.70, 1.09]**	0.04 [–0.15, 0.20]
13. I have a calmness that carries over into other aspects of my life	Ich habe eine Gelassenheit in mir, die sich auch auf andere Lebensbereiche überträgt	–0.04 [–0.19, 0.12]	–0.02 [–0.21, 0.18]	**0.75 [0.52, 0.98]**
15. I am more confident about facing challenges in other aspects of my life	Ich sehe anderen Herausforderungen in meinem Leben zuversichtlicher entgegen	–0.02 [–0.15, 0.10]	0.02 [–0.16, 0.18]	**0.90 [0.74, 1.08]**
16. I feel more influential in how events in my life unfold	Ich habe das Gefühl, mehr Einfluss auf die Entwicklung von Ereignissen in meinem Leben zu haben	0.04 [–0.08, 0.16]	0.00 [–0.17, 0.16]	**0.89 [0.73, 1.07]**
17. I feel better about my ability to bring about important outcomes in my life	Ich fühle mich gestärkt in meiner Fähigkeit, bedeutsame Ergebnisse in meinem Leben zu erreichen	0.04 [–0.09, 0.16]	–0.03 [–0.20, 0.13]	**0.93 [0.76, 1.09]**
18. I feel more able to prevent difficulties occurring in other aspects of my life	Ich fühle mich besser im Stande Schwierigkeiten in anderen Lebensbereichen zu verhindern	–0.02 [–0.14, 0.10]	0.06 [–0.12, 0.21]	**0.88 [0.72, 1.06]**

Loadings and 95% CIs on intended factors in bold text

choice of priors can affect the parameter estimates (Muthén & Asparouhov, 2012; Stenling, Ivarsson, Johnson, & Lindwall, 2015). To do so, we re-ran the final models for each inventory with smaller (0.05) and larger (0.015) priors for the cross-loadings, before comparing the parameter estimates for discrepancies between these models and those estimates with a prior variance of 0.01. We also weighted items with their respective factor loadings and then calculated Pearson's correlation coefficients to examine the relationships between subscale means.

Results

Model fit and convergence

Visual inspection of trace plots for all parameters supported convergence (i.e., showed good mixing and no upward or downward trends). In addition to this the PSR value for all models fell below 1.1 during the warm-up phase of the simulations and remained below 1.1 for the remaining iterations (**Table 1**), and there were no significant K-S tests for any of the five models.

For each G-SEAS inventory, the initial 18-item BSEM models with non-informative priors achieved adequate convergence and all items had significant loadings on their intended factors only. However, there were a myriad of other problems that meant the models were not deemed to be suitable. In the *Between* inventory, two items had problematic correlated residuals and one low major factor loading (0.49). In the *While* inventory, there were ten problematic correlated residuals and three major factor loadings were low (0.53–0.58). The three-factor *After* inventory had five problematic correlated residuals and one low major factor loading (0.56). The two-factor *After* model had one low major factor loading (0.56) and had 17 correlated residuals that exceeded their a priori limits. Through an iterative process, four items were removed from each G-SEAS inventory using the criteria outlined earlier (the remaining items can be seen in **Tables 2, 3 and 4**).

The BSEMs for the three 14-item G-SEAS inventories, the G-ACCSI, and the G-RTI with informative small variance priors for cross-loadings and residual correlations have excellent fit with PP*p* values of approximately 0.5 and having symmetric 95% posterior predictive CIs centered on zero (**Table 1**). The major factor loadings in each inventory were significant, acceptable, and in the hypothesized direction. Furthermore, there were no cross-loadings that exceeded their a priori limits (**Tables 2, 3, 4, 5 and 6**). There were

Table 5 German Risk-Taking Inventory (G-RTI) items and standardized factor loadings with 95% credibility intervals (CI) in brackets

Original item (Woodman et al., 2013)	German translation	Deliberate Risk-Taking	Precautionary Behaviors
1. I deliberately put myself in danger	Ich bringe mich bewusst in Gefahr	**0.81 [0.48, 0.97]**	0.01 [–0.17, 0.18]
2. It's like gambling, you can't win unless you try it	Es ist wie im Glücksspiel: wer nicht probiert, kann auch nicht gewinnen	**0.66 [0.24, 0.92]**	–0.02 [–0.20, 0.17]
3. I actively seek out dangerous situations	Ich suche gezielt gefährliche Situationen auf	**0.81 [0.54, 0.95]**	0.00 [–0.17, 0.17]
4. I take time to check conditions (e.g., weather)	Ich nehme mir Zeit, die Umweltbedingungen zu überprüfen (z. B.: Wetter)	–0.01 [–0.18, 0.18]	**0.72 [0.36, 0.91]**
5. I check any gear/equipment that I borrow	Ich überprüfe jeden Ausrüstungsgegenstand, den ich mir ausleihe	0.01 [–0.16, 0.18]	**0.75 [0.47, 0.93]**
6. I am aware of the nearest help and first aid	Ich weiß, wo sich die nächste Servicestelle und erste Hilfe befindet	0.03 [–0.15, 0.21]	**0.69 [0.26, 0.90]**
7. I take time to check for potential hazards	Ich nehme mir die Zeit, mich über mögliche Gefahren zu informieren	–0.04 [–0.21, 0.13]	**0.77 [0.53, 0.93]**

Loadings and 95% CIs on intended factors in bold text

Table 6 German Accidents and Close Calls in Sports Inventory (G-ACCSI) items and standardized factor loadings with 95% credibility intervals (CI) in brackets

Factor	Original item (Barlow et al., 2015)	German translation	Accidents	Close Calls
Close Calls	1. I experience close calls when participating in my sport	Ich entgehe Unfällen bei der Ausübung meines Sports nur knapp	**0.82 [0.54, 1.01]**	–0.01 [–0.20, 0.17]
	2. I find myself in situations that lead to near misses	Ich erlebe Situationen, die beinahe in Unfällen münden	**0.80 [0.55, 0.99]**	0.02 [–0.17, 0.21]
	3. During participation in my sport, I narrowly avoid accidents	Bei der Ausübung meines Sports gehe ich bis ans Limit wo Unfälle gerade noch vermieden werden können	**0.77 [0.48, 0.99]**	0.01 [–0.19, 0.20]
Accidents	4. I am involved in accidents when participating in my sport	Bei der Ausübung meines Sports bin ich in Unfälle involviert	0.04 [–0.16, 0.23]	**0.84 [0.62, 1.02]**
	5. My decisions in this activity lead to accidents	Meine Entscheidungen in dieser Aktivität führen zu Unfällen	–0.02 [–0.21, 0.16]	**0.84 [0.60, 1.03]**
	6. I sustain injuries as a result of accidents	Unfälle führen dazu, dass ich mir Verletzungen zuziehe	–0.02 [–0.21, 0.18]	**0.76 [0.45, 0.97]**

Loadings and 95% CIs on intended factors in bold text

no correlated residuals that exceeded their a priori bounds in the *Between*, *While*, three-factor *After* participation G-SEAS, G-RTI, or G-ACCSI. However, there were four correlated residuals that exceeded their a priori limits in the two-factor *After* inventory all in the Agentic Emotion Regulation factor; correlated residuals within a factor indicates that there is shared variance that is unaccounted for by the model (e.g., there is another latent factor influencing the data).

The DIC for the 14-item two-factor *After* model was 19,097.742 and the DIC for the 14-item, three-factor *After* model was 19,096.132, lower than that of the two-factor model despite having 16 more parameters. Despite the differences in DIC being small, the three-factor *After* model is a better fit to the data as there are no correlated residuals that exceed their a priori limits.

Model sensitivity

Sensitivity analyses for each inventory showed that the factor loadings and cross-loadings were relatively stable when specifying smaller (0.005) and larger (0.015) a priori variance priors. Using both smaller and larger prior variances 100% of discrepancies across the three inventories were within ±0.05, the maximum discrepancy was –0.043 with smaller prior variances set; and the maximum discrepancy was –0.029 with larger prior variances set.

Internal consistency, discriminant validity, and concurrent validity

Table 7 shows the latent factor subscale means, standard deviations, composite reliabilities and latent factor intercorrelations for the three G-SEAS inventories, the G-RTI, and the G-ACCSI. The composite reliability of each subscale resulted in $r > 0.8$ across each inventory and the subscales within each inventory were all positively correlated. The G-RTI subscales had a weak inverse relationship and the Accidents and Close Call subscales were positively correlated (0.61). None of the 95% CIs for interfactor correlations encompassed 1.00, thus, supporting the discriminant validity of the subscales within each inventory (Anderson & Gerbing, 1988).

Table 8 shows correlations between subscale means, where the items were weighted with factor loadings. Sensation seeking of the *Between* participation G-SEAS was positively correlated with DRT, accidents and close calls and negatively with PB and age. Accidents and close calls were positively correlated with sensation seeking, which was also negatively related to both PB and age.

Table 7 Latent factor subscale means, SDs, composite reliabilities and latent factor intercorrelations (95% CI)

Scale	Subscale	M	SD	CR	1	2
G-SEAS Between	1 Sensation seeking	3.00	1.46	0.91	–	–
	2 Emotion regulation	2.39	1.48	0.94	0.49 [0.32, 0.64]***	–
	3 Agency	2.30	1.44	0.93	0.34 [0.21, 0.56]***	0.79 [0.68, 0.86]***
G-SEAS While	1 Sensation seeking	3.20	1.11	0.84	–	–
	2 Emotion regulation	3.52	1.15	0.85	0.48 [0.27, 0.66]***	–
	3 Agency	3.62	0.75	0.83	0.38 [0.16, 0.57]***	0.51 [0.31, 0.67]***
G-SEAS After 3-factor	1 Sensation seeking	3.44	1.50	0.94	–	–
	2 Emotion regulation	3.65	1.55	0.95	0.59 [0.44, 0.72]***	–
	3 Agency	3.88	1.44	0.94	0.53 [0.36, 0.67]**	0.83 [0.74, 0.89]***
G-RTI	1 Deliberate risk-taking	4.21	1.94	0.80	–	–
	2 Precautionary behaviors	12.43	2.11	0.82	–0.22 [–0.43, 0.05]	–
G-ACCSI	1 Accidents	4.86	2.63	0.84	–	–
	2 Close calls	6.10	2.69	0.85	0.61 [0.41, 0.77]***	–

M Mean, *SD* Standard Deviation, *CR* Composite Reliabilities, *95% CI* 95% Credibility Interval, *G-SEAS* German Sensation Seeking, Emotion Regulation and Agency Scale, *G-ACCSI* German Accidents and Close Calls in Sports Inventory, *G-RTI* German Risk-Taking Inventory
$^{**}p < 0.01$, $^{***}p < 0.001$

Accidents and close calls were both positively correlated with DRT and negatively with PB. Age displayed negative correlations with all subscales except PB, which resulted in a weak positive relation.

Difficulty with emotion regulation as measured by the *Between* participation emotion regulation subscale, correlated positively with DRT, accidents, and close calls and negatively with PB and age.

Discussion

The aim of this study was to validate three different German versions of inventories in high-risk sports. The BSEM analyses supported a good model fit in all three scales (G-SEAS, G-RTI, G-ACCSI). All subscales of each inventory showed good internal consistency and supported good discriminant validity. The correlations between the G-RTI and G-ACCSI scales derived similar results as shown in the original paper (Barlow et al., 2015). While in the development of the original RTI and the ACCSI the relationship with the SEAS inventories was not tested, Barlow et al. (2015) tested the relationship between the original RTI, ACCSI, and alexithymia (i.e., difficulty describing, feeling, or identifying emotions). The relationships between alexithymia and the RTI and ACCSI were similar to the relationships between the *Between* emotion regulation subscale and the G-RTI and G-ACCSI subscales. These correlations suggest that a difficulty with emotion regulation is associated with higher deliberate risk-taking (i.e., the positive correlation of the G-SEAS *Between* emotion regulation and DRT and its negative correlation with PB (**Table 8**)). Deliberate risk-taking in the G-RTI correlated with the experience of Sensation Seeking in the G-SEAS as much as DRT in the RTI correlated with the Brief Sensation Seeking Scale (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002) in the study by Barlow et al., (2015). This suggests that there is a link between the motivations for participation in high-risk sport and participants' behaviors.

The factor structure of the original scales was replicated in the G-RTI and G-ACCSI (Barlow et al., 2015; Woodman et al., 2013) with similar factor loadings in the G-ACCSI and higher factor loadings in the G-RTI. Similarly, the factor structure of the original SEAS was replicated in the *Between* and *While* inventory of the G-SEAS replicated the factor structure of the original SEAS; Sensation Seeking, Emotion Regulation and Agency were shown as separate constructs (Barlow et al., 2013). This supports the view of a multidimensional construct of motivation in high-risk sports. In the analysis of the *After* inventory of the G-SEAS a three-factor BSEM was a better fit to the data than a two-factor BSEM as was found in the original SEAS *After* inventory, with satisfaction of sensation needs and agentic emotion regulation transfer as the two factors.

Four possible reasons for the difference in factor structure between the SEAS and G-SEAS are as follows: differences in analytical methods, translation bias, cross-cultural differences, and differences in sports included in the samples. Contrary to the SEAS analyses, the present analyses used BSEM, which allows more complex, and thus more realistic, models to be specified. BSEM was recently used by Niven and Markland (2016) to establish motivational factors in walking and was favored over the independent clusters model using a maximum likelihood approach to confirmatory factor analysis (ML-CFA ICM). The authors criticized the ML-CFA ICM approach because "ICM approach channels unspecified covariation between indicators through their factors, upwardly biasing interfactor correlations" (Niven & Markland, 2016, p. 97). This artificial inflation of interfactor correlations may be the reason why Barlow et al. (2013) rejected the three-factor model in the original SEAS *After* inventory. Given that emotion regulation and agency are conceptually related, a highly restrictive model (e.g., ML-CFA ICM) would be less suitable from a theoretical standpoint than a model that does allow for small cross-loadings and

Table 8 Weighted Pearson's correlations between the *Between* participation G-SEAS subscales, G-RTI subscales, G-ACCSI subscales, and age

	1	2	3	4	5	6	7
1 Sensation Seeking	–	–	–	–	–	–	–
2 Emotion Regulation	0.469***	–	–	–	–	–	–
3 Agency	0.374***	0.766***	–	–	–	–	–
4 Deliberate Risk Taking	0.476***	0.286***	0.217***	–	–	–	–
5 Precautionary Behaviors	–0.139***	–0.128***	–0.136**	–0.205***	–	–	–
6 Close Calls	0.495***	0.324***	0.228***	0.462***	–0.135**	–	–
7 Accidents	0.331***	0.227***	0.140***	0.353***	–0.109**	0.577***	–
8 Age	–0.394***	–0.279***	–0.223***	–0.278***	0.141***	–0.238***	–0.138***

G-SEAS German Sensation Seeking, Emotion Regulation and Agency Scale, *G-ACCSI* German Accidents and Close Calls in Sports Inventory, *G-RTI* German Risk-Taking Inventory
**$p < 0.01$, ***$p < 0.001$ (2-tailed)

residual correlations (e.g., BSEM with weakly informative priors). We only analyzed the data using BSEM; therefore, we cannot conclude how, if at all, factor structures may have been different when using ML-CFA ICM. However, if these differences in the factor structure are due differences in the analytical methods it may be that BSEM could reveal a three-factor structure in the *After* inventory of the original SEAS data.

Another possible explanation for the differences in items and factor structure could be due to translation bias and/or cross-cultural differences. Validation studies of translated health constructs repeatedly showed differences in factor structure and number of items (Hwang, Kim, Kim, Kim, & Ahn, 2013; Kim, DeCoster, Huang, & Bryant, 2013; Nagels et al., 2013). Cross-cultural differences were especially noticed between different ethnic populations, e.g., Korean and Greek (Hwang et al., 2013) or Hispanics and non-Hispanics (Sanchez & Vargas, 2016).

It is now evident that high-risk sport participants are not one homogenous population (Barlow et al., 2015, 2013; Castanier et al., 2010; Woodman et al., 2010); therefore, it is possible that differences in sports included the sample populations may account for the differences in factor structures between the G-SEAS and SEAS. The sample used by Barlow et al. (2013) included skydivers, mountaineers and low-risk sport participants; the sample in this study included paragliders, mountain runners, freeride skiers, freestyle skiers, and mountaineers. It was shown in the health surveillance of clinical populations that analyzing different clinical samples resulted in a different factor structure (Thaler et al., 2015). In the present study, participants from a wide range of high-risk sports have been included, going some way towards reflecting the heterogeneity of high-risk sport populations, thus, making the questionnaire usable for a large population.

The differences of the G-SEAS to the SEAS should not be considered as a negative outcome since the constructs showed a good model fit and the adjustments of the G-SEAS (shorter questionnaire, three factors for the *After* inventory) could be interpreted as improvements to the scale. Shorter questionnaires have higher response rates (Nakash, Hutton, Jørstad-Stein, Gates, & Lamb, 2006); therefore, response rates and adherence to the 14-item scale may be higher than to an 18-item scale. From a measurement perspective the three-factor structure of the *After* inventory presented in this article identifies emotion regulation and agency as two distinct transfer mechanisms in the current sample. Barlow et al. (2013) showed, using the two-factor solution in the *After* inventory that mountaineers experience a significant higher agentic emotion regulation transfer than both skydivers and low-risk controls. While participating, only the experience of emotion regulation could distinguish between mountaineers and skydivers which means that skydivers experienced similar feelings of agency while participating than mountaineers. This raises the question whether skydivers experience an agency transfer effect, which could not be shown in the study by Barlow et al. (2013) due to confounding results of emotion regulation and the limitation of a two-factor structure. Duration of the activity may be more important to the transfer of emotion regulation than agency. Freeride skiing comprises elements of thrill seeking (using lift-supported access for the activity) as well as a prolonged activity (using ski touring/hiking for the activity). Frühauf et al. (2017) reported that freeriders appreciate the fact that they are in charge of what they do and that they are not forced to follow strict rules (i.e., experience agency) and for some, this was crucial to their wellbeing (e.g., transfer effect of agency). The three-factor model in the G-SEAS *After* inventory might contribute to a better understanding of transfer effects from high-risk sports by offering the possibility to distinguish between agency and emotion regulation transfer effects in the German-speaking population for future studies using the G-SEAS.

Strengths and limitations

First, one might mention a lack of validation with established measures (e.g., the Sensation Seeking Scale). However, the concurrent validity of the inventories has been well established in the original since we validated constructs which already put those inventories in relation to established measures (Barlow et al., 2013; Woodman et al., 2013), validating the three scales with one another was seen as sufficient. Second, both the

exclusion of SEAS items and structural validation was done in the same sample. This approach might result in biased estimates for structural validation. Future studies using the G-SEAS might consider calculating indices for internal consistency and factorial structure. As discussed there are several strengths resulting from the differences in the factor structure of the G-SEAS; nevertheless, a limiting factor is that because of those differences, the G-SEAS and the original SEAS cannot be used to directly compare German- and English-speaking populations. This study has provided evidence for a three-factor structure for each of the G-SEAS scales. Without collecting new data in both German- and English-speaking populations to carry out a measurement invariance analysis, it is not possible to make direct comparisons between data collected using the SEAS and G-SEAS. We would recommend that this analysis be carried out using BSEM as the differences in factor structures of the SEAS and G-SEAS may be due to differences in analytic methodologies. Therefore, we recommend that G-SEAS should be used in German-speaking populations and should not be used to make direct comparisons with data collected using the SEAS. Interscale correlations do not differ between the 14-item and the 18-item German version; this suggests that despite missing 4 items, the G-SEAS still measures identical constructs. Another limitation which is not necessarily tied to this research only is the in our opinion problematic operationalization of high-risk sports. Despite the definition we cited at the beginning of the introduction, we think future research might benefit from a more detailed definition including additional components related to skills and experience. Though this is beyond the scope of this article, it is worth mentioning that researchers in high-risk sports need to address this problem in future studies.

This study has a number of strengths, including the variation within the population; in addition to being of sufficient size, the sample included a number of different high-risk sports, participants from a variety of experience levels and of different ages and sexes, thus, ensuring a heterogenic sample population. The analytical methods used in this study should also be seen as another strength of this article. It has been shown that BSEM is a more appropriate method than traditional CFA methods as it better reflects the complexities of reality (Niven & Markland, 2016; Stenling et al., 2015).

Conclusion

The current study validated three different inventories for high-risk sports in German language (G-SEAS, G-RTI, G-ACCSI) and showed good internal consistency, discriminant validity, and a good model fit in all scales. The BSEM analyzes support a 14-item three-factor structure of the G-SEAS despite the SEAS having a 18-item three-factor structure for *While* and *Between* and a two-factor structure for the *After* participation inventory (Barlow et al., 2013). The G-SEAS is seen as an improvement to the SEAS since shorter questionnaires increase response rates (Nakash et al., 2006) and a three-factor structure might help to distinguish between agency and emotion regulation transfer effects in future studies. However, a limiting factor of the differences in the factor structure is that the G-SEAS and SEAS cannot be used to directly compare German- and English-speaking populations with one another. Correlation analyses displayed relations between motivational and behavioral components of the high-risk sport activity with Sensation Seeking showing the highest correlation with deliberate risk-taking. The present study validated the three different inventories in German language, which is a first step towards the development of cross-cultural motivational and behavioral constructs in high-risk sport participants.

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Compliance with ethical guidelines

Conflict of interest. A. Frühauf, W.A.S. Hardy, R. Roberts, M. Niedermeier and M. Kopp declare that they have no competing interests.

The study was approved by the institutional Board for Ethical Questions in accordance with the Declaration of Helsinki.

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