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Personality, aggression, sensation seeking, and hormonal responses to challenge in Russian alpinists and special operation forces

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ABSTRACT

Male risk-taking behavior is associated with personality traits and correlates with hormone titers, notably for testosterone (T) and cortisol (C). Yet, these influences may be stronger in some individuals due to context or profession in which risk-taking occurs. We examine this possibility by investigating relationships of personality, aggression, and sensation seeking with T and C together with anthropometric measures in high risk-taking men: Russian alpinists (n = 55) and members of the Russian Special Forces (n = 33). They provided saliva samples before and after viewing a ~5 min video of aggressive male encounters and completed surveys after this task. After viewing the video, T increased in alpinists but decreased in Special Forces, and C increased in Special Forces. Alpinists scored higher than Special Forces in neuroticism and openness whereas Special Forces scored higher than alpinists in extraversion, agreeableness, and conscientiousness. Verbal aggression, anger, hostility, experience seeking, disinhibition, and boredom susceptibility were higher in alpinists than in Special Forces. Our findings suggest behavioral differences in high risk-taking men, influenced by profession-related individual differences in sensation seeking and hormonal response to challenges.

1. Introduction

Men score higher than women on measures of risk-taking behavior (Byrnes et al., 1999; Harris et al., 2006). These sex differences are present in childhood and increase during adolescence (Apicella et al., 2017; Hillier & Morrongiello, 1998). Sex differences in risk-taking are universal (Kruger & Nesse, 2004) and domain-specific (Hanoch et al., 2006; Weber et al., 2002; Wilke et al., 2014). Men score higher than women in evolutionarily relevant domains (e.g., mating-related behavior and status; Wilson & Daly, 1985) which may be a consequence of greater challenges for men than women in competitive settings (e.g., for access to mates) over evolutionary history. Thus, male risk-taking behavior may provide the opportunity to demonstrate dominance, confidence, ambition, and skill, and women prefer men with these traits because they facilitated ancestral reproductive success (Baker & Maner, 2008; Buss, 1994). A meta-analysis of sex differences in risk-taking (Byrnes et al., 1999) reported larger sex differences for physical risks (e.g., risky driving or certain sports activities). Men's greater physical risk-taking is associated with abilities and skills that require physical strength and athleticism (Farthing, 2005; Petraitis et al., 2014) and may signal the ability to acquire or retain resources.

Research in risk-taking has identified sensation seeking as a key contributory component (Breivik, 1996; Fischer & Smith, 2004; Nicholson et al., 2005; Zuckerman, 1979). Sensation seeking denotes the search for "varied, novel, complex, and intense experiences and feelings, including the readiness to take risks for the sake of such experiences" (Zuckerman, 1979, 1994). Sensation seeking is not always associated with risk behavior; high sensation seeking individuals may attempt to minimize risk, and low sensation seeking does not always indicate unwillingness to take risks (Roberti, 2004). Thus, it is important to distinguish "risk taking" as a temporary state which marks the acceptance of a risky decision, and "risk attitude" as a passion for risky behavior (Ilin, 2012; Vrubleuski, 2017; Weber & Johnson, 2009). The latter suggests that such behavior reflects a stable construct (i.e., a personality trait). In other words, risk-taking is caused by a stable characteristic (primarily, sensation seeking) and a desire for exposure

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to physical danger, which is observed, for example, in representatives of extreme recreational activities. Risk readiness, in contrast, refers to the motivated willingness to take appropriate risks, such as in an emergency by professional rescuers, firefighters, and soldiers.

Research documents relationships of male risk-taking behavior with testosterone (T) and cortisol (C), which moderate risk-taking propensity. The effect of T manifests in a greater propensity for certain types of risky behavior (Apicella et al., 2015; Kurath & Mata, 2018; Mazur & Booth, 1998; Ronay & Von Hippel, 2010; Van Honk et al., 2011; Van Honk & Schutter, 2007). C is released in unfamiliar situations associated with negative emotions, social conflict, or in response to physical and environmental threats. C concentration can reflect individual differences in the hypothalamic-pituitary-adrenal axis that underlies aggression, socialization, and adaptation to stress (Hardy, 2019; Kirschbaum et al., 1993; McBurnett et al., 2000; Van Bokhoven et al., 2005). According to the dual-hormone hypothesis, the effect of T on social behavior depends on C, suggesting that T correlates positively with certain behaviors only when C is low (Carré & Mehta, 2011; Casto & Edwards, 2016; Mehta et al., 2008; Mehta et al., 2015; Mehta & Josephs, 2010; Mehta & Prasad, 2015; Montoya et al., 2012; Pfattheicher, 2017; Popma et al., 2007). Thus, the T:C ratio may predict status-relevant behavior (including aggression, competition, and dominance), which correlates positively with risk-taking (Ellis et al., 2012; Wilson et al., 2002). Accordingly, in men, T is positively associated with self-reported risk-taking when C is low (Mehta et al., 2015). However, two recent meta-analysis (Dekkers et al., 2019; Grebe et al., 2019) found only marginal support for the dual-hormone hypothesis, with a small effect size of the T × C interaction on status-relevant behavior (including risk-taking).

In the present study, we investigated personality, aggression, sensation seeking, and T and C response to "challenge" in men exposed to greater risks, i.e., Russian alpinists and members of the Russian Special Forces. These groups share a higher than average level of risk-taking due to their professional or recreational activity, but differ in their risk-taking motivation. Alpinists search for occasional thrills and experiences, whereas Special Forces regularly take risks as part of their professional activities (Apalkova et al., 2018). There may be dispositional or contextual variables that account for these differences in risk-taking motivation (Weber & Johnson, 2009). By examining behavioral/personality profiles (including hormonal reactivity to "challenge") of high risk-taking men differing in their professional background, we aimed to demonstrate individual differences among high risk-taking men, thus suggesting that risk-taking is not unitary.

Following previous reports on personality in alpinists and military personnel (Apalkova et al., 2018; Darr, 2011), we expected personality differences, with alpinists scoring higher in neuroticism, extraversion, and openness but lower on agreeableness and conscientiousness than Special Forces. Moreover, we expected to detect differences in sensation seeking, with alpinists scoring higher than Special Forces in thrill and adventure seeking and experience seeking. For aggression, we expected higher scores for verbal aggression, anger, and hostility in alpinists and higher scores in physical aggression for Special Forces. We hypothesized that increases in T and C after a challenge would differ for alpinists and Special Forces, with the latter showing a larger increase in C compared to alpinists. Previous research on hormonal changes in response to a challenge reported a relationship of digit ratio (2D:4D) – a hypothesized proxy of prenatal T (Manning et al., 1998) – with the T change after challenge (Crewther et al., 2015; Kilduff et al., 2013; Manning et al., 2014; Ribeiro et al., 2016). A low 2D:4D (indicating high prenatal T) correlated with a larger T change after challenge. Moreover, 2D:4D ratio is associated with several personality traits including risk-taking (Fink et al., 2006; Garbarino et al., 2011; Hönekopp, 2011; Stenstrom et al., 2011). Thus, we secured measurements of right- and left-hand 2D:4D to investigate relationships of prenatal androgenization with risk-taking.

2. Materials and methods

2.1. Participants

We obtained anthropometric and personality information together with hormonal profiles from 88 Russian men aged 19–49 years (M = 31.08, SD = 6.04). The data were collected at a mountaineer base camp in Northern Caucasus, Kabardino-Balkaria, Russia, as part of a larger anthropological study. The camp is located ~2200 m above sea level and is surrounded by alpine peaks > 5000 m. Participants were Russians citizens (by self-report), either alpinists (n = 55, ages 19–49 years, M = 30.65, SD = 6.60) or members of the Special Forces (n = 33, ages 24–46 years, M = 31.79, SD = 4.99) who use the camp for training in that particular environment. Alpinists had a qualification of three or higher on the 6-categories of the Russian Mountaineering Federation. Members of Special Forces reported regular involvement in combat operations.

2.2. Measures

2.2.1. Anthropometric measurements

Participants' height (m), weight (kg), circumferences of chest, waist, and hip (cm), and handgrip strength (HGS; kgf) of right and left hands were recorded. HGS measurements were recorded in duplicate (with ~1 min rest between first and second measurement) and the larger value was used for the analysis. Finger lengths of right and left hand index (2D) and ring (4D) fingers were measured directly from the palms with a digital caliper (Lux Tools, GmbH & Co. KG) to an accuracy of 0.01 mm. Length measurements of fingers were recorded in duplicate and the mean of first and second measurement of each finger was used for calculating 2D:4D (digit ratio).

2.2.2. Surveys

Participants self-reported information about their personality, aggression, and sensation seeking, in addition to sociodemographic information (e.g., age). Personality was assessed using the Russian translation of the NEO-FFI inventory (Costa & McCrae, 1985, 1992; Kudryashev, 1992). The NEO-FFI is a widely-used 60-item inventory designed to secure quick, reliable, and valid assessments of the five dimensions of adult personality. It yields scores for neuroticism, extraversion, openness, agreeableness, and conscientiousness. Responses to individual items range from 0 ("strongly disagree") to 4 ("strongly agree"), and each dimension is comprised of 12 items. For the assessment of aggression, we used the Russian adaptation of the Buss-Perry Aggression Questionnaire (BPAQ; Buss & Perry, 1992; Butovskaya et al., 2013). The BPAQ is a 29-item survey assessing four dimensions of aggression (physical aggression, verbal aggression, anger, hostility). Participants answer statements relating to these dimensions on a 5-point Likert-type scale from "extremely uncharacteristic of me" to "extremely characteristic of me". Sensation seeking was assessed with the Russian adaptation of the Sensation-Seeking Scales, Form V (SSS-V; Zuckerman et al., 1978; Zuckerman, 1994; Egorova & Piankova, 1992). The SSS-V consists of 40 forced-choice statements designed to assess optimal level of stimulation. Respondents must choose between two possibilities or situations, one representing a high propensity for sensation seeking and the other, the opposite tendency. The SSS-V can be scored as a general measure of sensation seeking by summing responses to all items, and also can be scored along four 10-item factors, i.e., thrill and adventure seeking, experience seeking, disinhibition, and boredom susceptibility.

2.2.3. Aggression video

Participants viewed a ~5-min video showing aggressive rugby tackles of men by men, with sound (https://www.youtube.com/watch?v=UTg1Xm9CJgo). The video was provided by John Manning (Swansea University) and used in previous studies investigating short-

term endocrine changes in relation to 2D:4D and aggression (e.g., Kilduff et al., 2013; Crewther et al., 2015; Ribeiro et al., 2016). The video was presented on a 15.4 inch laptop computer and sound was provided via earphones. Participants viewed the video individually and privately.

2.2.4. Saliva collection and hormone analysis

A saliva sample was collected from each participant when he completed the sociodemographic questions, i.e., shortly after arriving at the testing facility. Three further saliva samples were collected within 15 min after viewing the aggression video (with ~5 min difference between each sample). The saliva samples were collected in sterile 1–2 ml containers ("Salicaps") and were stored at −20 °C immediately following completion of data collection for each participant. For assessment of T (pmol/l) and C (nmol/l) concentrations, probes were thawed and the three samples collected after viewing the aggression video were pooled. The samples were then centrifuged (1500 ×*g* for 10 min) to remove precipitated mucins and other particulate matter, and the clear undiluted saliva samples were analyzed for T and C in duplicate using enzyme immunoassay (ELISA) commercial kits for Testosterone Saliva (DBC Cat. No. 749-4001) and Cortisol Saliva (DBC Cat. No 749-2001) (Biochemmack, Moscow; http://www.biochemmack.ru).

2.3. Procedure

A trained anthropologist (Y. A.) with an assistant collected data during a period of ~3 weeks in August 2017. Participants in the base camp were recruited verbally and, if they agreed to participate, a time/date for data collection was scheduled (normally within 1–2 days). After arrival at the testing location (an office in the camp), participants were introduced to the study procedure and informed that participation was voluntary and unrewarded. Written consent was obtained from all participants.

Testing sessions were scheduled between 11:30 am and 4:30 pm to minimize effects of circadian hormonal fluctuations (e.g., "morning peaks"; Guignard et al., 1980). Data collection duration was ~1 h per participant. Participants first completed the sociodemographic questions; then, anthropological measurements were secured along with an initial salivary sample. Next, participants viewed the aggression video and provided three further saliva samples. Finally, participants completed the NEO-FFI, the BPAQ, and the SSS-V. All participants were debriefed and provided with contact information should they have questions about the study. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki for research involving human subjects. The study protocol was approved by the Institute of Ethnology and Anthropology, Russian Academy of Sciences, Moscow, and permission was obtained from the director of the mountaineering camp in Kabardino-Balkaria.

3. Results

Descriptive statistics of the study variables are reported in Tables 1–3, for the total sample, and separately for alpinists and Special Forces (including *t*-tests for simple comparisons between these two groups).

Age and anthropometric measures did not differ between alpinists and Special Forces (Table 1). The concentration of C and the T:C ratio at baseline were lower in Special Forces than in alpinists (Table 2). No other differences in concentrations of circulating T and C were found between the groups. There were differences in the before-after challenge comparisons of hormonal concentrations for T and the T:C ratio in the total sample. After viewing the video, T was lower, C was higher (albeit *n.s.*), and the T:C ratio was lower (T: $t(87) = 3.75$, $p < .001$, $d = 0.40$; C: $t(87) = -1.82$, $p = .07$, $d = -0.20$; T:C ratio: $t(87) = 3.48$, $p < .001$; $d = 0.37$). Considering alpinists and Special Forces separately revealed similar patterns, but with a significant change of C in Special Forces and no significance for the T:C change in alpinists (alpinists: T: $t(54) = 3.12$, $p < .01$, $d = 0.42$; C: $t(54) = -0.45$, $p = .66$, $d = -0.06$; T:C ratio: $t(54) = 1.70$, $p = .10$; $d = 0.23$; Special Forces: T: $t(32) = 2.05$, $p < .05$, $d = 0.36$; C: $t(32) = -2.96$, $p < .01$, $d = -0.52$; T:C ratio: $t(32) = 3.54$, $p < .001$; $d = 0.62$) (Fig. 1a–c).

Table 1
Descriptive statistics for age and anthropometric measures for the total sample ($n = 88$) and separately for alpinists ($n = 55$) and Special Forces ($n = 33$).

	Total sample Mean (*SD*)	Alpinists Mean (*SD*)	Special Forces Mean (*SD*)	*t*	*p*
Age	31.08 (6.04)	30.65 (6.60)	31.79 (4.99)	−0.851	0.397
Height	1.78 (0.07)	1.79 (0.07)	1.78 (0.06)	0.860	0.392
Weight	76.25 (9.56)	76.00 (10.41)	76.67 (8.08)	−0.315	0.753
Chest	97.15 (6.89)	96.19 (7.07)	98.80 (6.33)	−1.722	0.089
Waist	81.33 (6.89)	80.64 (6.93)	82.53 (6.75)	−1.242	0.218
Hips	98,10 (5.38)	97.87 (5.63)	98.48 (4.99)	−0.509	0.612
WHR	0.83 (0.04)	0.82 (0.04)	0.84 (0.05)	−1.405	0.164
BMI	23.91 (2.48)	23.71 (0.36)	24.26 (0.39)	−0.989	0.325
HGS right	51.35 (8.48)	51.08 (8.43)	51.80 (8.67)	−0.384	0.702
HGS left	47.95 (7.25)	47.16 (6.51)	49.27 (8.27)	−1.325	0.189
2D:4D right	0.964 (0.03)	0.964 (0.03)	0.963 (0.03)	0.151	0.880
2D:4D left	0.968 (0.03)	0.970 (0.03)	0.965 (0.03)	0.831	0.414

Note: *t*-values produced by independent-means tests of difference between alpinists and Special Forces.

Several personality and behavioral measures differed between the two groups (Table 3). Alpinists scored higher on neuroticism and openness, whereas Special Forces scored higher on extraversion, agreeableness, and conscientiousness. Verbal aggression, anger, and hostility were higher in alpinists than in Special Forces, whereas no difference was found for physical aggression (Table 3). Experience seeking, disinhibition, and boredom susceptibility were higher in alpinists than in Special Forces. Thrill and adventure seeking did not differ between the groups.

Multivariate analyses of (co-)variance were conducted separately for personality, aggression, and sensation seeking as dependent measures, "group" (alpinists vs. Special Forces) as a fixed factor, and right/left hand 2D:4D, T and C, and the T:C ratio as covariates. The concentrations of T and C (and the T:C ratio) entered in these analyses were those obtained from saliva samples after viewing the video because i) the samples were collected while participants completed the surveys, and ii) T and C concentrations were pooled from three samples and may therefore reveal individual differences more accurately than a single measurement.

For personality, there was a multivariate effect of group ($F(5,77) = 10.23$, $p < .001$, $\eta^2 = 0.40$), and an effect of right 2D:4D ($F(5,77) = 3.26$, $p < .01$, $\eta^2 = 0.18$). Other effects failed to reach statistical significance (all $F < 2.08$, all $p > .07$). Univariate statistics revealed effects of group on all five personality dimensions (neuroticism: $\eta^2 = 0.29$, extraversion: $\eta^2 = 0.07$, openness: $\eta^2 = 0.07$, agreeableness: $\eta^2 = 0.09$, conscientiousness: $\eta^2 = 0.26$), and effects of right and left 2D:4D for neuroticism (right: $\eta^2 = 0.05$, left: $\eta^2 = 0.05$) and agreeableness (right: $\eta^2 = 0.07$, left: 0.06). Bonferroni corrected pairwise tests indicated alpinists > Special Forces for neuroticism ($p < .001$) and openness ($p < .05$), and alpinists < Special Forces for extraversion ($p < .05$), agreeableness ($p < .01$) and conscientiousness ($p < .001$).

For aggression, there was a multivariate effect of group ($F(4,78) = 9.05$, $p < .001$, $\eta^2 = 0.32$). Other effects failed to reach statistical significance (all $F < 2.18$, all $p > .08$). Univariate statistics revealed effects of group on anger ($\eta^2 = 0.06$) and hostility ($\eta^2 = 0.29$). Right 2D:4D showed an effect on verbal aggression ($\eta^2 = 0.05$) and hostility (right: $\eta^2 = 0.07$), and left 2D:4D showed an effect on hostility ($\eta^2 = 0.07$). No effects were detected for measures of circulating T and C, or the T:C ratio (all $F < 1.42$, all $p > .024$). Bonferroni corrected

Table 2
Descriptive statistics for testosterone (T) and cortisol (C) concentrations, and the T:C ratio before and after watching the aggression video for the total sample (n = 88) and separately for alpinists (n = 55) and Special Forces (n = 33).

	Total sample Mean (*SD*)	Alpinists Mean (*SD*)	Special Forces Mean (*SD*)	*t*	*p*
Baseline T	238.65 (35.89)	238.24 (31.60)	239.34 (42.62)	−0.139	0.890
Baseline C	62.17 (33.76)	69.15 (36.85)	50.53 (24.19)	2.584	< 0.05
Baseline T:C	5.06 (3.05)	4.54 (2.77)	5.93 (3.35)	−2.114	< 0.05
After challenge T	229.53 (36.36)	227.92 (32.60)	232.23 (42.30)	−0.537	0.593
After challenge C	67.16 (33.51)	70.85 (35.38)	61.00 (29.64)	1.340	0.184
After challenge T:C	4.26 (2.30)	4.05 (2.33)	4.61 (2.25)	−1.100	0.275
T change	−9.12 (22.83)	−10.32 (24.52)	−7.11 (19.90)	−0.637	0.539
C change	4.99 (25.65)	1.70 (28.03)	10.47 (20.33)	−1.566	0.121
T:C change	−0.80 (2.16)	−0.49 (2.12)	−1.32 (2.15)	1.784	0.078

Note: *t*-values produced by independent-means tests of difference between alpinists and Special Forces. T was measured in pmol/l and C in nmol/l.

pairwise tests showed alpinists > Special Forces for hostility ($p < .05$) and anger ($p < .001$), but no differences for physical aggression ($p = .65$) or verbal aggression ($p = .11$).

For sensation seeking, there was a multivariate effect of group ($F(4,78) = 5.15$, $p < .001$, $\eta^2 = 0.21$). Other effects failed to reach statistical significance (all $F < 1.04$, all $p > .39$). Univariate statistics revealed effects of group on experience seeking ($\eta^2 = 0.14$), disinhibition ($\eta^2 = 0.15$) and boredom susceptibility ($\eta^2 = 0.08$). No effects were detected for measures of circulating T and C, the T:C ratio, or right/left 2D:4D (all $F < 32.87$, all $p > .09$). Bonferroni corrected pairwise tests indicated alpinists > Special Forces for experience seeking and disinhibition (both $p < .001$), and boredom susceptibility ($p < .05$) but no difference for thrill and adventure seeking ($p = .37$).

Table 4 shows correlations among the dependent variables of personality, aggression, and sensation seeking, separately for alpinists and Special Forces. Because of the relatively small sample sizes, these relationships should be considered with caution and regarded as complementary information rather than as hypothesis tests. Thus, we did not apply corrections for multiple testing. There were a number of expected relationships among the dependent variables within and between the scales of the surveys for both alpinists and Special Forces. Of 156 correlations in total, 61 were > ± 0.20 and 58 had the same sign in both groups. Forty-two correlations were significant at $p \leq .05$, and 11 of these significant correlations were detected in both groups. Some patterns may be of particular interest. In Special Forces, hostility showed significant correlations with all five personality dimensions, whereas in alpinists hostility correlated with just two of the five personality dimensions (neuroticism and agreeableness). Thrill and adventure seeking correlated positively with extraversion and openness in Special Forces but not in alpinists. Experience seeking in Special Forces (but not in alpinist) correlated positively with physical aggression. Boredom susceptibility in alpinists showed significant positive correlations with all four aggression scores. No such relationships were detected in Special Forces. Finally, correlations among sensation seeking scores were lower or absent in alpinists compared with Special Forces.

Table 5 reports zero-order correlations of personality, aggression, and sensation seeking with T, C, the T:C ratio, and right/left 2D:4D in alpinists and Special Forces. Of 130 correlations in total, 24 were > ± 0.20 and 42 had the same sign in both groups. Six correlations were significant at $p \leq .05$ but none of these significant correlations was detected in both groups. In alpinists, extraversion correlated negatively with right and left 2D:4D, openness correlated negatively with T, conscientiousness correlated negatively with right 2D:4D, and disinhibition correlated negatively with left 2D:4D. In Special Forces, there was a negative correlation between thrill and adventure seeking and the T:C ratio.

We performed a binary logistic regression (forward likelihood) with "group" (alpinists vs. Special Forces) as dependent variable and hormonal changes (before vs. after challenge), 2D:4D, personality, aggression, and sensation seeking scores as independent variables. This resulted in a significant model ($\chi^2(4) = 55.58$, $p < .001$; Nagelkerke $R^2 = 0.64$) with an overall of 83% correct classifications of group membership (alpinists 85.5% and Special Forces 78.8%). The following variables were included in the final equation: neuroticism, conscientiousness, hostility, and experience seeking (neuroticism: B (SE) = 0.15 (0.08), $\chi^2(1) = 3.82$, OR = 1.16, 95% CI [1.00, 1.34]; conscientiousness: B (SE) = −0.18 (0.07), $\chi^2(1) = 5.84$, OR = 0.84, 95% CI [0.73, 0.97]; hostility: B (SE) = 0.17 (0.08), $\chi^2(1) = 5.09$, OR = 1.19, 95% CI [1.02, 1.38]; experience seeking: B (SE) = 0.37 (0.19), $\chi^2(1) = 3.94$, OR = 1.45, 95% CI [1.01, 2.10]; constant: B (SE) = −0.25 (3.21), $\chi^2(1) = 0.01$, OR = 0.78). Thus, an increase in conscientiousness results in a decreased probability that the individual

Table 3
Descriptive statistics for personality, aggression, and sensation seeking measures for the total sample (n = 88) and separately for alpinists (n = 55) and Special Forces (n = 33).

	Total sample Mean (*SD*)	Alpinists Mean (*SD*)	Special Forces Mean (*SD*)	*t*	*p*
Neuroticism	15.74 (6.71)	18.55 (5.73)	11.06 (5.54)	6.003	< 0.001
Extraversion	31.32 (7.59)	29.51 (7.45)	34.33 (6.94)	−3.017	< 0.01
Openness	30.15 (4.83)	31.15 (4.98)	28.48 (4.12)	2.584	< 0.05
Agreeableness	27.80 (7.27)	26.49 (5.06)	29.97 (4.89)	−3.162	< 0.01
Conscientiousness	34.22 (7.27)	31.24 (6.52)	39.18 (5.58)	−5.831	< 0.001
Physical aggression	22.38 (5.52)	22.18 (5.26)	22.70 (5.99)	−0.422	0.674
Verbal aggression	14.67 (3.81)	15.29 (3.82)	13.64 (3.61)	2.006	< 0.05
Anger	13.66 (4.83)	14.58 (4.92)	12.12 (4.34)	2.372	< 0.05
Hostility	18.42 (5.63)	20.76 (4.67)	14.52 (4.91)	5.962	< 0.001
Thrill and adventure seeking	7.80 (1.10)	7.98 (1.99)	7.48 (2.00)	1.133	0.260
Experience seeking	4.99 (2.19)	5.64 (2.20)	3.91 (1.74)	3.848	< 0.001
Disinhibition	4.61 (2.38)	5.31 (2.32)	3.45 (2.03)	3.793	< 0.001
Boredom susceptibility	2.94 (1.83)	3.35 (1.65)	2.27 (1.96)	2.755	< 0.01

Note: *t*-values produced by independent-means tests of difference between alpinists and Special Forces.

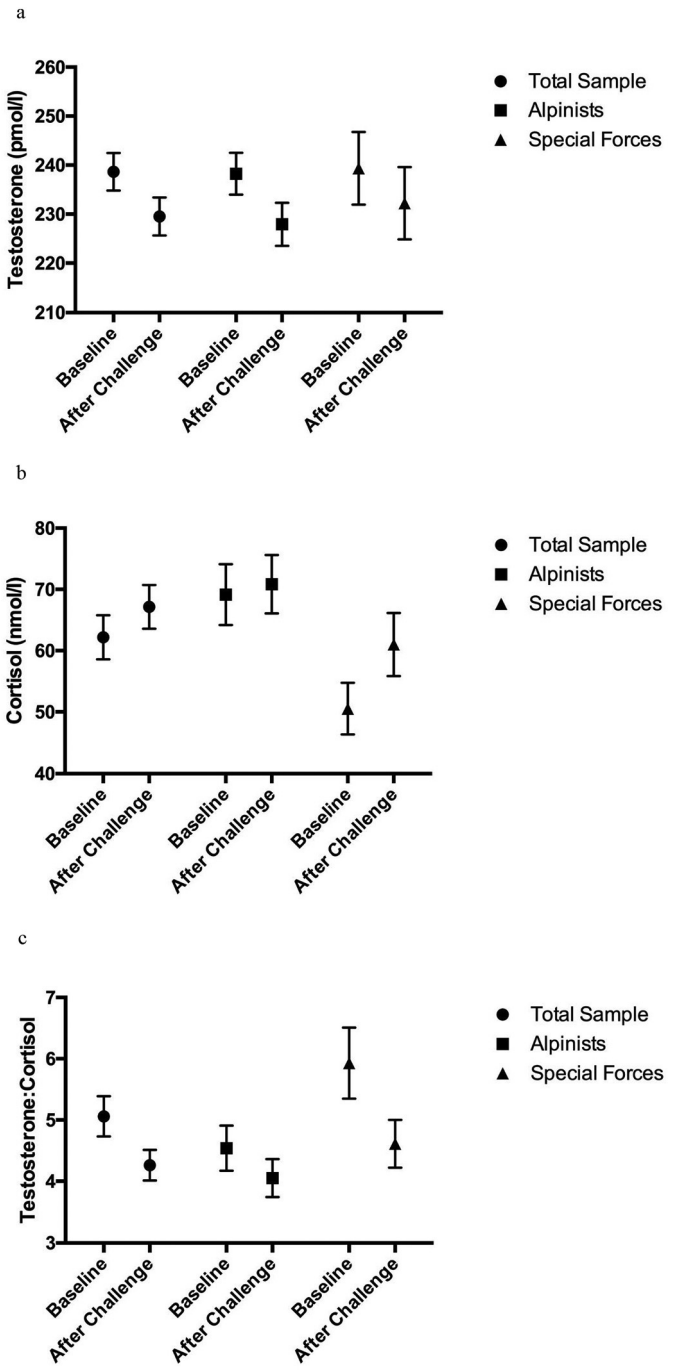

Fig. 1. Testosterone (a), cortisol (b), and the testosterone:cortisol ratio (c) at baseline and after challenge in the total sample (n = 88), and separately for alpinists (n = 55) and Special Forces (n = 33).

is an alpinist (as compared to a member of the Special Forces), whereas neuroticism, hostility, and experience seeking contribute positively to this probability.

4. Discussion

We investigated personality, aggression, and sensation seeking in a sample of high risk-taking men, i.e., Russian alpinists and members of the Russian Special Forces. In addition, we collected T and C information in response to a challenge condition. Previous research reported differences in this combined group of high risk-taking men in comparison to a control group (Apalkova et al., 2018), suggesting positive relationships of male risk-taking with measures of physical and psychological masculinity (Kasielska-Trojan et al., 2017; Kurath & Mata, 2018). There were no differences in anthropometry between the two groups, and we therefore did not investigate group-specific relationships of anthropometric traits with personality, aggression, or sensation seeking. Likewise, there were few differences between the two groups in hormonal measures, although we noted differences in baseline C (alpinists > Special Forces) and the T:C ratio (Special Forces > alpinists). Viewing the aggression video (i.e., the challenge condition) led to a decrease in T and an increase in C, the latter in Special Forces but not in alpinists. Differences between the groups were found for several measures of personality, aggression, and sensation seeking, with multivariate effects confirming these differences independent of T, C, and T:C, and the 2D:4D ratio. Some traits in particular contributed to the prediction of "group membership" (alpinists vs. Special Forces); with an accuracy of 83%, neuroticism, conscientiousness, hostility, and experience seeking predicted correct group assignment.

Our findings suggest that risk-taking depends on professional context. We predicted that the two groups of risk-prone men would differ in certain personality traits and in risk-taking motivation, thus suggesting that risk-taking is not unitary. We identified differences in several personality traits and behavioral measurements: Alpinists scored higher on neuroticism and openness, whereas Special Forces scored higher on extraversion, agreeableness, and conscientiousness. Alpinists scored higher in verbal aggression, anger and hostility, and in experience seeking, disinhibition, and boredom susceptibility.

These results are consistent with the results of previous research. For example, in U.S. Navy SEALs, more experienced individuals scored lower on extraversion and higher on conscientiousness than less experienced individuals. Compared to norms for adult males, SEALs scored lower in neuroticism and agreeableness, average to lower in openness, and higher in extraversion and conscientiousness (Braun et al., 1994). Another study of Special Forces of the Italian police (compared to norms for adult males) documented higher scores in emotional stability and lower scores in depression, anxiety, exhaustion, and loss of empathy (Garbarino et al., 2012). Egan and Stelmack (2003) reported that Mount Everest climbers had higher scores in extraversion and psychoticism but lower scores in neuroticism (compared to scores for a normative sample). This finding is in contrast to that in our alpinists' sample. However, it should be noted that at high altitudes (> 7000 m) mountaineering exposes humans to biological and psychological stress (e.g., Ryn, 1988) that is not comparable to those in Caucasus in the camp where data were collected at an altitude of ~2200 m. Moreover, individual differences in rock climbers have been reported (Llewellyn & Sanchez, 2008), thus reminding researchers not to assume homogeneity within risk-taking populations. Rock climbers high in self-efficacy (i.e., "the belief in one's capabilities to organize and execute the course of action required to produce given attainments"; Bandura, 1997) were found to take greater risks. Llewellyn and Sanchez (2008) obtained negative associations of risk-taking with sensation seeking, which was counter to their expectations given previous research on sensation seeking and impulsiveness - both of which are related to conscientiousness (Aluja et al., 2004; Zuckerman, 1994). In the current study, two groups with different risk-taking motivations also differed in sensation seeking. Alpinists scored higher in three of the four sensation seeking scales. Only thrill and adventure seeking did not differ between the groups. Our findings contradict those reported in Llewelyn and Sanchez, although it should be noted that we did not collect information about self-efficacy.

Llewelyn and Sanchez (2008) state that the link between conscientiousness and domain-specific risk-taking may reflect the importance of being mindful about the influence of one's risk-orientation on others. We found that in predicting group membership (alpinist vs. Special Forces), conscientiousness was one of the significant dimensions, with Special Forces scoring higher (and hostility correlating negatively with conscientiousness in Special Forces only). Together with

Table 4
Inter-correlations of dependent variables personality, aggression, and sensation seeking, separately for alpinists (n = 55) and Special Forces (n = 33).

		1	2	3	4	5	6	7	8	9	10	11	12	13
1. Neuroticism	Alpinists	–												
	Special Forces	–												
2. Extraversion	Alpinists	−0.204	–											
	Special Forces	−0.485**	–											
3. Openness	Alpinists	0.078	0.094	–										
	Special Forces	−0.040	0.316	–										
4. Agreeableness	Alpinists	−0.232	0.180	−0.097	–									
	Special Forces	−0.280	0.184	0.097	–									
5. Conscientiousness	Alpinists	−0.129	0.376**	−0.161	−0.097	–								
	Special Forces	−0.666**	0.516**	0.098	0.252	–								
6. Physical aggression	Alpinists	0.039	0.105	−0.188	0.004	0.042	–							
	Special Forces	0.185	−0.091	0.184	−0.246	−0.089	–							
7. Verbal aggression	Alpinists	0.260	0.083	0.095	−0.393**	0.278*	0.400**	–						
	Special Forces	0.223	−0.199	0.077	−0.590**	−0.163	0.621**	–						
8. Anger	Alpinists	0.343*	0.045	0.131	−0.184	−0.108	0.424**	0.333*	–					
	Special Forces	0.013	−0.210	−0.061	−0.273	−0.243	0.625**	0.595**	–					
9. Hostility	Alpinists	0.489**	−0.170	−0.012	−0.332*	0.011	0.139	0.309*	0.295*	–				
	Special Forces	0.479**	−0.475**	−0.345*	−0.449**	−0.384*	0.212	0.367*	0.197	–				
10. Thrill and adventure seeking	Alpinists	−0.071	0.161	0.053	0.058	−0.217	0.309*	0.262	0.083	0.155	–			
	Special Forces	−0.115	0.476**	0.475**	−0.260	0.154	0.187	0.220	0.025	−0.115	–			
11. Experience seeking	Alpinists	0.028	0.104	0.222	−0.047	−0.166	0.067	−0.014	0.268*	0.029	0.461**	–		
	Special Forces	−0.051	0.282	0.290	−0.096	−0.063	0.363*	0.184	0.254	0.068	0.561**	–		
12. Disinhibition	Alpinists	0.116	0.153	0.134	−0.312*	−0.062	0.153	0.161	0.136	0.201	0.218	0.352**	–	
	Special Forces	0.306	0.308	0.193	−0.310	−0.054	0.130	0.100	−0.141	0.214	0.505**	0.569**	–	
13. Boredom susceptibility	Alpinists	0.131	0.117	0.177	−0.179	−0.011	0.459**	0.404**	0.455**	0.326*	0.008	0.107	0.320*	–
	Special Forces	0.042	0.207	0.204	−0.260	−0.016	0.047	0.103	−0.078	0.060	0.492**	0.485**	0.699**	–

* $p < .05$.
** $p < .01$.

Table 5
Correlations (Pearson *r*) of dependent variables personality, aggression, and sensation seeking with hormonal measures and 2D:4D, separately for alpinists ($n = 55$) and Special Forces ($n = 33$).

		T	C	T:C ratio	2D:4D right	2D:4D left
1. Neuroticism	Alpinists	0.051	−0.158	0.076	−0.039	0.071
	Special Forces	−0.171	0.271	−0.169	−0.285	0.101
2. Extraversion	Alpinists	0.161	−0.125	0.170	−0.349**	−0.310*
	Special Forces	−0.072	−0.254	0.052	0.076	−0.075
3. Openness	Alpinists	−0.278*	0.014	−0.033	0.005	−0.181
	Special Forces	−0.143	−0.179	−0.075	0.026	0.054
4. Agreeableness	Alpinists	0.154	−0.154	0.105	0.235	−0.027
	Special Forces	0.318	−0.094	0.203	0.168	0.001
5. Conscientiousness	Alpinists	0.129	−0.117	0.113	−0.269*	−0.163
	Special Forces	−0.124	−0.321	0.103	0.115	−0.307
6. Physical aggression	Alpinists	−0.009	−0.055	0.051	−0.030	0.095
	Special Forces	−0.008	−0.078	0.204	−0.019	0.080
7. Verbal aggression	Alpinists	−0.033	0.182	−0.177	−0.249	−0.061
	Special Forces	−0.255	0.117	−0.243	−0.142	0.012
8. Anger	Alpinists	−0.168	−0.019	−0.033	−0.168	−0.083
	Special Forces	0.029	−0.038	0.120	0.038	−0.011
9. Hostility	Alpinists	−0.115	−0.111	−0.086	−0.256	0.002
	Special Forces	−0.111	0.307	−0.203	−0.061	0.128
10. Thrill and adventure seeking	Alpinists	−0.145	0.199	−0.127	−0.143	−0.059
	Special Forces	−0.246	−0.348*	0.049	−0.145	0.033
11. Experience seeking	Alpinists	−0.110	0.062	−0.032	−0.123	−0.080
	Special Forces	−0.133	−0.036	0.018	−0.106	0.088
12. Disinhibition	Alpinists	−0.124	−0.017	−0.114	−0.255	−0.282*
	Special Forces	−0.114	−0.104	0.070	−0.077	0.205
13. Boredom susceptibility	Alpinists	−0.185	−0.103	−0.036	−0.123	0.019
	Special Forces	−0.106	−0.075	−0.039	−0.137	0.071

* $p < .05$.
** $p < .01$.

the findings of alpinists scoring higher on neuroticism, experience seeking, and hostility, this may indicate that "mindfulness" is more pronounced in Special Forces than in alpinists. Zuckerman (1994) states that conscientiousness "may have evolved in humans living in social groups with explicit rules for approved behaviors" (p. 172). It seems that behavior in military settings is particularly characterized by high levels of conscientiousness, and can predict (together with extraversion and openness) military training performance (Dean et al., 2006). Conscientiousness correlated negatively with neuroticism, verbal aggression, and hostility in Special Forces, which may be interpreted as further evidence for personality difference between the two groups causing "mindful" behavior.

Previous research has investigated links between personality traits and hormonal predictors of risk-taking behavior in different groups, including extreme athletes and special military units (Arazi et al., 2018; Fave et al., 2003; Kjærgaard et al., 2013; Kozieł et al., 2018; Massimino et al., 2019). Several findings document that high sensation seekers have a higher neuroendocrine response to a stressor (Freeman & Beer, 2010; Rosenblitt et al., 2001). However, few empirical studies have investigated the relationship of sensation seeking to C responsivity in a challenge condition, and these results are inconsistent (Frenkel et al., 2018; Rimmele et al., 2007; Shabani et al., 2011). The present study did not detect effects of T or C (or the T:C ratio) on personality, aggression, and sensation seeking; in addition, hormonal measures did not contribute to predicting group membership. We predicted differences between alpinists and Special Forces for T and C increases after a challenge, with the latter showing a larger (but non-significant) increase in C compared to alpinists. The challenge led to lower levels of T and higher levels of C in the combined sample (alpinists and Special Forces) and in the Special Forces sample alone. This finding is consistent with previous findings of hormonal responses to military-related stress. For example, Morgan et al. (2000) reported increased C and decreased T after stress exposure (military survival training) with effects depending on the type of stressors (e.g., interrogations, problem solving).

Previous studies suggest that from an evolutionary perspective, male physical risk-taking offers benefits (e.g., status) under certain circumstances; thus, high risk-takers may display higher circulating T levels and lower 2D:4D (higher prenatal T) (Garbarino et al., 2011; Ronay & Von Hippel, 2010; Stenstrom et al., 2011). These studies typically compared a sample of high risk-takers with a control group, whereas the sample for the present study comprised high risk-takers with different professional backgrounds (but no control group). Although some differences in hormonal response to "challenge" between alpinists and Special Forces were noted (e.g., an increase of C after challenge in Special Forces), they had no explanatory power in predicting group membership or differences in personality, aggression, and sensation seeking. Digit ratio had some influence on personality and aggression measures. A meta-analysis documented a negative but small relationship of 2D:4D with aggression (Hönekopp & Watson, 2011), and although 2D:4D correlations with the Big Five factors have been reported (e.g., Austin et al., 2002; Fink et al., 2004), the evidence for an association is less conclusive. In the current study, we controlled for hormonal influences when assessing differences in personality, aggression, and sensation seeking between alpinists and Special Forces. Yet, there were differences in these measures, which leads us to the suggestion that individual differences between alpinists and members of the Special Forces are dispositional rather than contextual. However, we note that dispositions and contextual effects on individual differences co-occur. While dispositions may explain individual differences, contextual experiences may influence dispositions (e.g., Lengua et al., 2019). Thus, it is difficult to differentiate between the two effects, as a true experiment involving only individual differences is not possible due to participants' self-selection (Hoyle & Leary, 2009). Challenge conditions may cause changes in T and C levels, and especially C responsivity may differentiate types of risk-takers. Watching a rugby video may not be "challenging" enough to cause a robust endocrine response in high risk-taking men; thus, it remains to be clarified whether the observed group differences in C response are real.

The results of this study corroborate previous research documenting important individual differences among high risk-taking individuals (e.g., Fave et al., 2003; Llewellyn & Sanchez, 2008). There were differences in personality, aggression, and sensation seeking between

alpinists and members of the Special Forces that were not predicted by hormonal measures. Future research might investigate the causes of individual differences among high risk-taking men, preferably in real-life settings, and clarify the role of self-selection vs. disposition in vocational context.

CRediT authorship contribution statement

Yulia Apalkova: Conceptualization, Investigation, Data curation, Writing - original draft. **Marina L. Butovskaya:** Project administration, Funding acquisition, Conceptualization, Methodology, Wrtiting - review and editing. **Todd K. Shackelford:** Writing - review & editing. **Bernhard Fink:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing.

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