Adaptive Human Behavior and Physiology (2022) 8:263–279
https://doi.org/10.1007/s40750-022-00186-8

ORIGINAL ARTICLE

Skin Conductivity Responses to Images of War and Sports in Men and Women: An Evolutionary Perspective

Marián Hosťovecký[1] · **Jan Riegert**[2] · **Adam Pazda**[3] · **Pavol Prokop**[4,5]

Received: 3 December 2021 / Revised: 14 January 2022 / Accepted: 18 January 2022 /
Published online: 26 January 2022

Abstract

Objectives The male warrior hypothesis suggests that men have evolved psychological mechanisms to form aggressive coalitions against members of outgroups, which may explain men's propensity to engage in warfare, as well as team sports. We examined gender differences in skin conductivity and attitudes toward war after exposing participants to video imagery depicting sports and war from a sample of young adults from Slovakia.

Methods We measured skin conductivity responses using electrodermal activity (EDA) when participants watched three short videos: Football, World War II, and Control. Then, implicit and explicit attitudes toward war and subjective arousal of the three videos were examined using questionnaires.

Results Men showed higher maximal skin conductivity when watching a team sport video, compared to a control video. Skin conductivity during a war video did not significantly differ from a sport or control video. In contrast, women showed highest maximal skin conductivity when watching a war video, followed by the sport and control videos, but these differences were not statistically significant. When the videos were subjectively rated by the same participants, men rated team sports and war as similarly arousing, but ratings of these videos were not significantly different for women.

Conclusions These results suggest that visual cues of warfare and team sports influence skin conductivity, but we did not find support for the hypothesis that sport is a substitute for war. Because this study was based exclusively on visual cues, we discuss additional possibilities that could influence future investigations.

Keywords Human evolution · Football · Male warrior hypothesis · Skin conductivity

Extended author information available on the last page of the article

Introduction

Violent intergroup conflict, or warfare, where organized actions of members of one group results in the killing of conspecifics in a rival group, has been documented in humans as well as in social primates, lions, wolves, and hyenas (Crofoot & Wrangham, 2010; Manson et al., 1991; Wilson & Wrangham, 2003). Some researchers suggest that warfare evolved deep in our evolutionary past, at least 100,000–200,000 years ago (Wu et al., 2011; Wu & Trinkaus, 2015), but reliable archaeological evidence supporting the occurrence of warfare exists only for the last 10,000–12,000 years (Lahr et al., 2016). This suggests that intergroup violence may have shaped the selection process of social behaviour (Bowles, 2009; Majolo, 2019).

The male warrior hypothesis (MWH) suggests that men have evolved psychological mechanisms to form aggressive coalitions against members of outgroups, ultimately leading to the acquisition or protection of reproductive resources (Ji et al., 2021; McDonald et al., 2012). Male, but not female, involvement in war defined by MWH is explained by gender-specific costs and benefits from engagement in intergroup aggression via parental investment and reproductive success. Compared to men, women are less likely to support war (Wilcox et al., 1996), violence in media (Pew Research Center, 2013), and the use of torture (Lizotte, 2015). Furthermore, women show a lower preference for weapons (Geary, 1998; Sulikowski & Burke, 2014) and for war scenes in computer games (Schwarz et al., 2019). Given that war possesses significant reproductive costs to women in terms of rape, unwanted pregnancy, and/or infanticide (Thornhill & Palmer, 2000), women are expected to be more fearful and avoidant towards formidable outgroup males than men are (McDonald et al., 2012). Men, on the other hand, may benefit from war in terms of enhanced access to women, food, and new territories that ultimately increases their reproductive success (McDonald et al., 2012; Van Vugt; et al., 2007).

Some evolutionary theorists suggest that sports are akin to training for hunting and war, which consequently enhances material resources and access to mates (Livingstone Smith, 2007; Lombardo, 2012), or that sports directly contribute to acquiring status and prestige (Furley, 2019). Indeed, there are many similarities between sports and war. Male athletes in competitive sports achieve higher financial status and access to women, relative to men who do not engage in sports (Faurie et al., 2004; Lombardo, 2012; Schulte-Hostedde et al., 2008). Both athletes and warriors are desired by women (Escasa et al. 2010; Miller et al., 1998; Schulte-Hostedde et al., 2008) and have more sexual partners (Chagnon, 1988; Macfarlan et al., 2014; Glowacki & Wrangham, 2015) by means of increased social status and power (Furley, 2019; Glowacki & Wrangham, 2013; Hames, 2020; Shavers et al., 2015; Thirer & Wright, 1985).

In this study, we investigated whether viewing a team sport elicits similar physiological reactions as viewing war in a modern society by assessing electrodermal activity (EDA). The physiological basis of EDA is an autonomic (involuntary) reaction that occurs in the skin and subcutaneous tissue in response to changes in emotion (Dawson et al., 2007), particularly under the influence of the cholinergic sympathetic system (Kreibig, 2010). EDA increases with excitement, exemplified by the sweaty palms one may experience before an exhibition. In line with the MWH, we predicted that EDA responses to sport and war imagery would be gender specific. If team sports are a substitute for war, men should show similar physiological excitement and militant attitudes when viewing sport and war imagery, and this excitement should be lower when viewing neutral imagery. In contrast, women are expected to show greater physiological excitement (but less-militant attitudes) toward war, compared with a team sport, as women are generally more fearful and avoidant of dangerous outgroup males than men are (McDonald et al., 2012). Because team sports are certainly less harmful or deadly than war (Furley, 2019), and do not pose a physical risk to women, viewing sport imagery should not lead to female excitement or militant attitudes.

Materials and Methods

Participants

Before the research started, the study was approved by the faculty board. Using a convenience sampling strategy, we recruited 64 students (38 men and 26 women) from a middle-sized university (Mean age = 24.48 years; range = 20–41). Participants were asked by the first author to participate in research using EDA technology, but all were blind to our hypotheses. Participation was voluntary and unpaid. After the research concluded, participants were debriefed about the research goals, thanked, and dismissed.

At the beginning of the experiment, respondents were instructed to complete a measure assessing their current mental and physical conditions. Respondents who did not meet specific criteria were excluded from the experiment. The following assessments were included in the questionnaire: (1) woman's menstruation period (applicants with menstrual bleeding were not included); (2) arrive to the laboratory in the morning on an empty stomach; (3) no consumption of alcohol, energy drinks, antidepressants, anti-anxiety drugs, sleeping pills, coffee etc. in the preceding 24 h; (4) to have slept well for the preceding three days and (5) if the respondent had had any traumatic experience/s between measurements for the experiment. None of the selected participants indicated trouble sustaining attention. We excluded one participant who reported to have a serious mental illness. The experimental session date of five female participants was changed to avoid days with menstrual bleeding.

Procedure

Data were collected at the end of the winter semester of the 2019/2020 academic year. Before the research began, participants were informed of the general experimental procedure, and all provided informed consent. Participants were examined individually in a quiet room. Measurement always started at the same time in the morning between 8–11am. Before entering the laboratory, each participant turned off her/his cell phone and left it in the waiting room on the table. The lighting conditions were uniform for all participants, who were seated in an armchair with a backrest (Kołodziej et al., 2019). The seat was adjusted vertically until the participant´s thighs were parallel to the ground. The room temperature was constant, ranging from 20 to 21 °C. There was just one computer in the room. Each participant was asked to wash his/her hands for 5 s or longer, dry their hands thoroughly, and sit down.

According to Ramirez (2020), EDA data can be acquired by using 2 or 3 electrodes, and there are multiple locations at which these signals can be accessed. We utilized pre-gelled, disposable snap electrodes EL507 for measurement of electrodermal activity (BIOPAC 2020a). The latex-free electrodes conformed and adhered well to fingers. On the left-hand fingers (index finger and middle finger), electrodes were attached (on distal phalanx) with a SS57L unshielded electrode lead, from which an electrical signal proportional to the change in the skin conductance (SC) was acquired (BIOPAC 2020b). After that, the participant relaxed with open eyes for approximately 2 min. The SC signal registration rate was 1 kHz, which represented 1,000 samples per second (120,000 samples per one video length of 2 min). After instructing participants about the course of the experiment, the supervisor left the room, moved to the waiting room, and started the video remotely.

Participants were asked to watch a short video, which was presented on a 24-inch LCD monitor in full screen mode. The user's eye distance from the center of the screen was approximately 55–65 cm. The videos were randomly selected from one of the following possibilities: (1) Sports match (football match score 5:0, all five goals were shown in the video; hereafter referred to as Sport) (2) World War II (Saving Private Ryan movie war scene; hereafter referred to as War) and (3) Control video (videotaped people on the street, hereafter referred to as Walk). The total length of each video was 120 s (for examples of the course of skin conductivity within each sex and experiment category, see Supplementary material 1). Each video clip was presented without sound or music, and participants wore earmuffs to reduce any possible noise in the room. Each respondent participated in the experiment three times (each time with a different video segment) in a random order with a minimum 7-day interval between sessions.

Football was selected for the sport condition for the purpose of this study because it is the most frequently watched team sport throughout the world (FIFA, 2015). The sport video depicted a football match between FC Barcelona and Real Madrid (also known as El Clasico) which took place on 29. November 2010. We chose this football match because both clubs are famous, successful, and have a number of popular players (e.g., Messi, Xabi, Ronaldo, Ramos, Casillas). The fan attendance at the football stadium was very high (more than 98% of the total capacity), and Barcelona "demolished" Real Madrid 5-0, which provides a parallel example between winners and losers in a similar fashion to war.

The War video was comprised of a dynamic Normandy landing scene from the famous movie Saving Private Ryan. We removed downtimes (e.g., soldiers waiting for the beginning of the fight), and we left war scenes depicting machine gun shooting of soldiers, cannon fire from allied ships, and the end of the battle with dead bodies in the sea.

The control (walk) video was chosen to keep human movement consistent with the experimental videos. We videotaped people visiting markets on a street in Trnava city showing no evident emotions which could be compared with the football or war videos.

Three months after the experiment finished, the same participants were asked to rate how arousing they found each of the three videos to be on a scale from 1 (not at all) to 6 (extremely arousing) via an online questionnaire (43 participants responded to this follow-up request). All participants were debriefed following the study.

Hardware

The BIOPAC MP36 unit was used as a data acquisition system to measure electrodermal activity (EDA). Skin responses are well-known proxies for the intensity of emotions (Bechara & Damasio, 2005; Boucsein, 2012; Dawson et al., 2007). The MP36 has an internal microprocessor to control data acquisition and communication with the computer. The system features accurate built-in universal amplifiers and 24-bit A/D converters (Biopac). Additionally, the acquisition unit includes an electrode check input while measuring the impedance between the EDA electrode and skin. The skin-electrode impedance was less than 10 kΩ.

Research Questionnaires

The first section of the questionnaire contained demographic data about the participant (age, nationality, gender, field of study, attitude towards sports (Do you like sports?), football (Do you like football?), and documentaries about World War II (Do you like documentaries about World War II?). These questions were scored on a 6-point Likert scale with higher numbers indicating stronger agreement. The second section of the questionnaire examined explicit and implicit attitudes toward war with countries that could be potentially dangerous to Slovakia (e.g., Hungary, Russia, Turkey). Twelve questions focused on engaging in war (explicit attitudes, e.g. If Hungary invaded us, I will go to war with them; Cronbach $\alpha = 0.95$) and 12 questions on trade conflict (implicit attitudes, e.g., If Hungary enters a trade conflict with us, I will sign petitions to protest; Cronbach $\alpha = 0.96$). These items were modified from Chang et al. (2011). Again, the questions were scored on the 6-point Likert-type scale with higher points indicating stronger endorsement. The questionnaire was completed online by the participants.

Statistical Analyses

We computed generalized linear mixed models (GLMM) using the lmer function (Lme4 package) in R 4.0.2 (R Core Team 2020) to assess the effect of independent variables (gender and experimental condition) on median, minimal, and maximal skin conductivity with indices for implicit war and explicit war as additional dependent variables. Since we found negligible variability in the age of our participants (85.7% were aged between 20 and 25 years), we did not further consider this variable for analyses. We first built null models for each dependent variable and included participants as a random factor. These null models also included scores from the attitudinal questions on affinity for sports, football, and documentary movies from the Second World War as random factors. Next, we built models to separately test the effects of our independent variables (gender and experimental condition). We also modelled the interaction of these variables. We compared all three models with the null model and chose the most suitable model based on percentage of variability explained. Data from subjective ratings of videos was also analysed with GLMM where the median rating score was treated as a dependent variable, gender and experimental condition were predictors, and the participant's ID was defined as a random factor. Post-hoc comparisons were computed using lsmeans package in R using the function lsmeans (Lenth, 2016).

We performed power analyses using the simr package in R (Greem & MacLeod, 2016) to estimate the probability of incorrectly failing to reject the null hypotheses for different numbers of respondents (40, 50, 60, 70, 80, 90 and 100) and for our analyses with 63 respondents. The power of these analyses was expressed by percentages, and the trends were fitted using a distance weighted least squares method in Statistica 13 software (TIBCO Software Inc., 2017). To show the course of the measured skin conductivity during the experiment, we created example graphs from original values for each sex and experimental condition. All graphs were made using Statistica 13 software.

Table 1 GLMM models with tested person and their affinity to sport, football and World War II used as random factors/covariates

Dependent variable	Independent variable	d.f.	% of explained variability	Chi	*p*
Median skin conductivity	Experiment	8	0.2	1.7	0.423
	Sex	7	0.1	1.4	0.242
	Experiment×sex	11	0.4	4.2	0.527
Minimal skin conductivity	Experiment	8	0.5	6.5	**0.039**
	Sex	7	0.2	2.3	0.126
	Experiment×sex	11	0.8	10.1	**0.073**
Maximal skin conductivity	Experiment	8	0.8	10.7	**0.005**
	Sex	7	0.6	8.2	**0.004**
	Experiment×sex	11	1.6	20.6	**<0.001**
Explicit war	Experiment	8	1.2	6.3	**0.042**
	Sex	7	0.6	3.2	**0.074**
	Experiment×sex	11	2.3	12.1	**0.034**
Implicit war	Experiment	8	0.3	1.4	0.502
	Sex	7	0.6	3.1	**0.077**
	Experiment×sex	11	1.0	5.1	0.409
Subjective video rating	Experiment	4	1.0	5.3	**0.021**
	Sex	5	19.5	99.2	**<0.001**
	Experiment×sex	8	22.9	115.9	**<0.001**

Results

Skin Conductivity

Median skin conductivity was not significantly affected by gender, experimental condition, or their interaction. Similarly, we did not find any effect on these variables on the implicit war index (Table 1).

Minimal skin conductivity changed significantly across experimental conditions and marginally by the interaction between gender and experimental condition (Table 1). However, using the post-hoc tests, we found that the only gender difference entailed women in the walk condition having higher minimal skin conductivity than men in the sport condition (Fig. 1).

Maximal skin conductivity was significantly affected by the experimental condition, gender, and their interaction (Table 1). Using post-hoc tests, we found that maximal skin conductivity was significantly or marginally lower in women in the walk condition than for men in the sport and war conditions, respectively. Further, the maximal skin conductivity was significantly lower in the sport condition for women compared to the same condition for men. Finally, we found that maximal

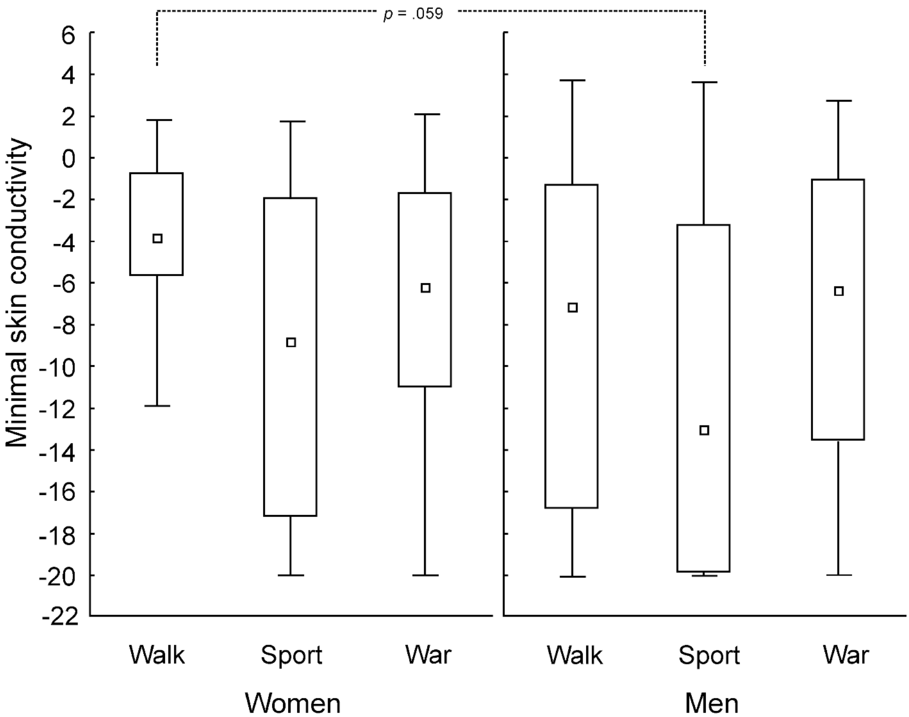

Fig. 1 Minimal skin conductivity during each experiment for men and women separately. Square—median, box—25–75% of data, whiskers—non-outlier range. Broken line connects categories, where values show a marginally significant difference. *P* value is indicated

skin conductivity was lower for men in the walk condition than it was for men in the sport condition (Fig. 2). An interesting difference was found between patterns in men and women. For women, we found increasing maximal skin conductivity among the experimental conditions from walk to war. However, for men, the maximal skin conductivity was highest for the sport condition (Fig. 2). In summary, the MWH was not statistically supported because men did not show the highest maximum excitement in the war condition (relative to the walk condition), and women showed no difference between the war and sport conditions.

Attitudes for explicit war were significantly affected by experimental condition and approaching significance by gender. We also found a significant interactive effect between condition and gender (Table 1). Using post-hoc tests, we did not find any significant differences between the categories. However, the overall values of explicit war attitudes were generally higher for women compared to men (Fig. 3). These results also failed to support the MWH hypothesis.

Power analyses showed that the model for maximal skin conductivity as the dependent variable and the interaction of sex and condition as independent variables

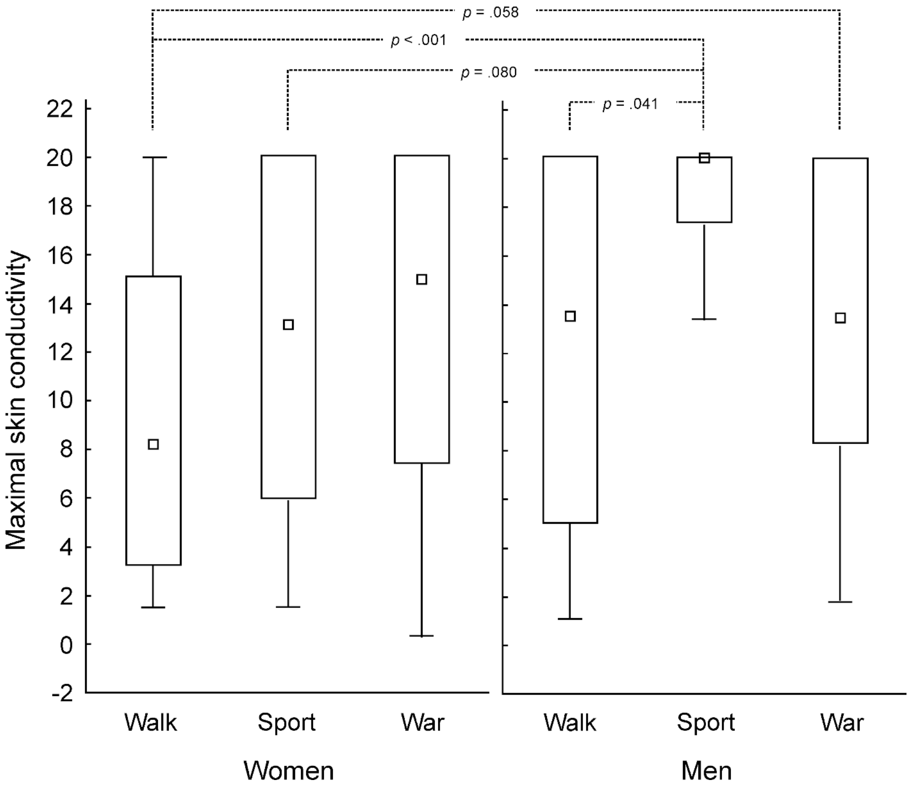

Fig. 2 Maximal skin conductivity during each experiment for men and women separately. Square—median, box—25–75% of data, whiskers—non-outlier range. Broken lines connect categories, where values show a marginally significant difference. *P* values are indicated

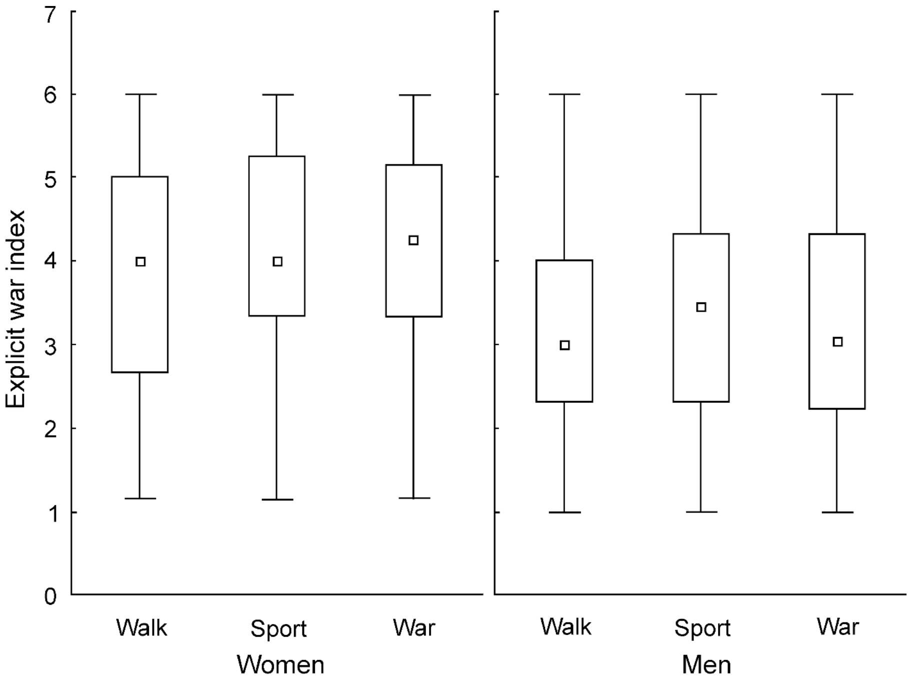

Fig. 3 "Explicit war" indices in each experiment for men and women separately. Square—median, box—25–75% of data, whiskers—non-outlier range

was the strongest. The simulation showed that involving fewer or more respondents would achieve similar power (93.0–98.0%). The model for minimal skin conductivity as the dependent variable and the interaction of sex and condition as independent variables was less powerful (64.0–72.0%) but involving more respondents would not improve the power of analysis considerably. The highest variability of power (62.5–94.8%) was found for the model with explicit war attitudes as the dependent variable and the interaction of sex and condition as independent variables. In this model, involving 100 respondents would increase the power by 16.8% (Fig. 4).

Subjective Measures

Subjective ratings of videos differed with respect to the experimental condition, gender, and their interaction (Table 1). Men perceived the war and sport videos as significantly more arousing than women (Table 2), while the control video was rated by men and women similarly (post-hoc $p=0.920$, Fig. 5). War and sport videos were rated by men similarly (Table 2), while the war video tended to be rated by women as more arousing, but not significantly) than the sport video (post-hoc $p=0.07$). These results failed to provide full support for the MWH hypothesis.

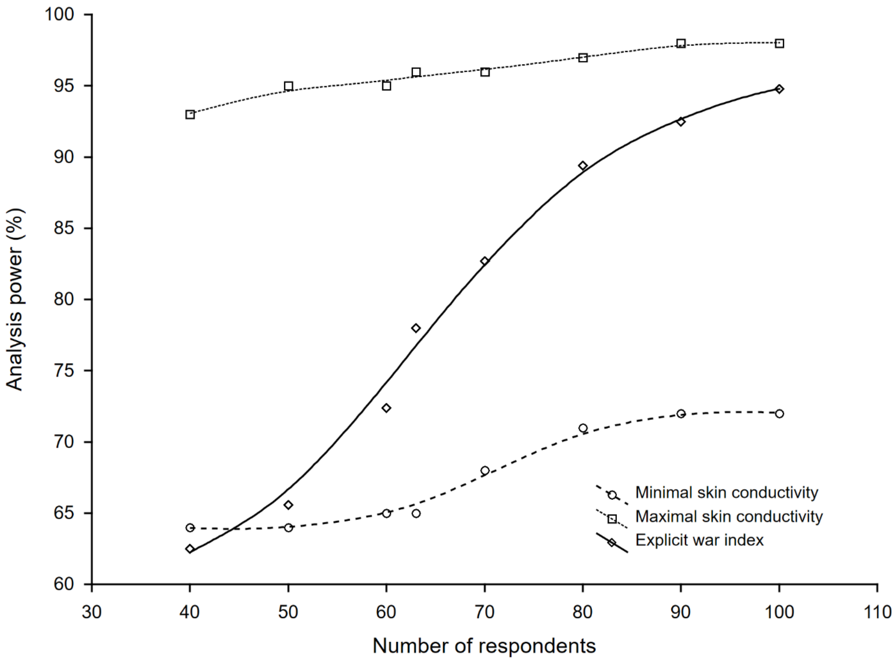

Fig. 4 Simulation of analyses power for models with three dependent variables (maximal and minimal skin conductivity, explicit war) explained by interaction of sex and experiment under different number of respondents (n=63 respondents were used for our analyses). Distance weighted least squares method was used to fit the curves

Table 2 Post-hoc analyses for subjective ratings of three types of videos by participants

	Walk f	Sport f	War f	Walk m	Sport m
Sport f	<0.001				
War f	<0.001	0.071			
Walk m	0.916	<0.001	<0.001		
Sport m	<0.001	<0.001	0.72	<0.001	
War m	<0.001	<0.001	0.011	<0.001	0.394

Discussion

The findings of this study suggest that visual perception of a team sport and war stimulated different levels of excitement as measured by EDA in men and women. Specifically, women showed stronger maximal skin conductivity when primed with war, while men showed maximal skin conductivity when primed with a team sport. These results were not influenced by attitudes toward sports, football, or by preferences for watching movies about World War II. Watching videos depicting war or a team sport did not influence militant attitudes in either gender. These results generally failed to support the MWH because the highest maximum physiological excitement in the war condition was not significantly different from the control condition

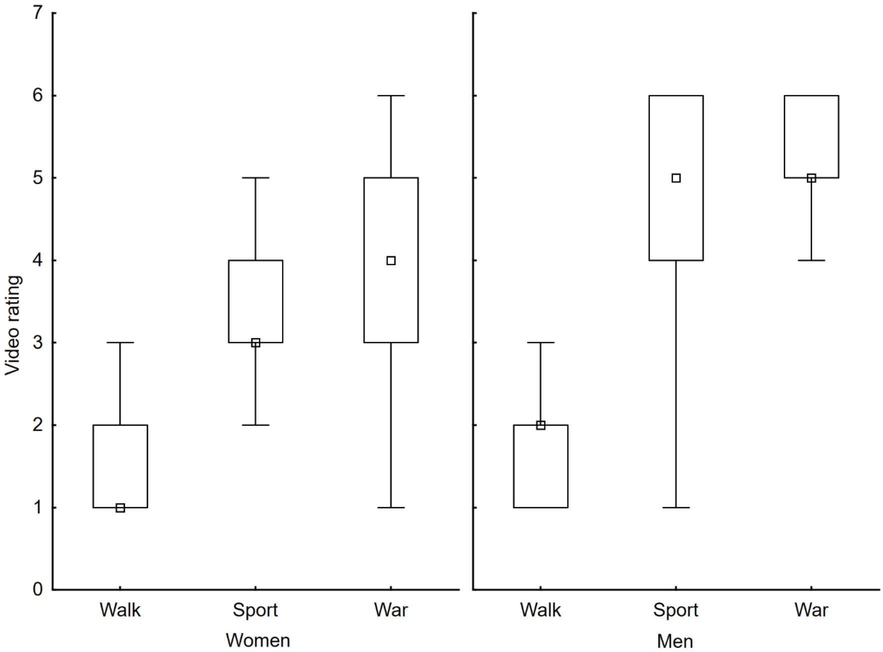

Fig. 5 Subjective ratings of videos by males and females and for each experiment. Square—median, box—25–75% of data, whiskers—non-outlier range

in men, and women failed to show stronger excitation when viewing the war video, relative to the sport video. Although subjective ratings showed that men perceived the team sport and war video as similarly arousing (which agrees with the MWH), women showed no significant difference in self-reported arousal between the war and sport videos ($p=0.07$). Thus, the MWH was generally not supported.

The MWH posits that men have evolved psychological mechanisms to form formidable coalitions against members of outgroups (e.g., Ji et al., 2021; McDonald et al., 2012), and the same requirement is necessary in team sports (Lombardo, 2012; Scalise Sugiyama et al., 2020). In other words, male motivations to form coalitions and compete with out-groups via sports reflects a need to engage in aggressive or potentially deadly warfare. This might explain why the most popular sports largely depend on war-relevant skills (Winegard & Deaner, 2010). However, men showed non-significant differences in maximal skin conductivity when shown videos depicting war or team sports, and there was also no difference between the war and control videos. This finding does not support the idea that the relative importance of sports increased because male engagement in warfare has progressively decreased (Lombardo, 2012). In contrast, subjective ratings fully corroborated the sport as a substitute for war idea because the team sport video elicited similar arousal ratings by men as the war video. Women tended to report stronger subjective arousal after watching the war video, but their maximum autonomic responses were not significantly different across conditions. This suggests that subjective ratings did not fully correspond with skin conductivity measures.

There are several possible explanations for why we did not find the hypothesized pattern of results for our EDA data. First, sports may have evolved as by-product of status seeking (Furley, 2019) and do not originate from training for primitive war as suggested by certain evolutionary theorists (Livingstone Smith, 2007; Lombardo 2012). Second, we used imagery depicting modern warfare, rather than ancient warfare, assuming that this would be easier for modern Western participants to understand (Todd K. Shackelford, pers. comm., December 4, 2019). However, it is possible that priming men with hunter-gatherer's warfare, which is likely more similar to ancient warfare and reliably originated at the beginning of Holocene period (Lahr et al., 2016), could produce different results than depictions of modern warfare. Third, perhaps supplementation of EDA measures with heart rate would provide more sensitive measures than skin conductance alone (e.g., Adam et al., 2012). It is an open question as to whether subjective ratings correspond better with heart rates than with skin conductivity.

Moreover, emotional responses recorded with EDA are strongly context dependent. For instance, players' emotional responses when playing violent scenes in a first-person shooter game resulted in high arousal as indexed by increased EDA activity, but passively watching the same negative game events (e.g., falling and death of the player's own character) induced negative responses (Ravaja et al., 2006, 2008). A recent study of Holm et al. (2021) additionally showed that players who disliked first-person shooter games showed increased levels of EDA compared with those who preferred shooting games. This means that supplementary measures are required for correct interpretation of results. Here we used self-reports to better understand the nature of differences in reactions to imagery depicting sports and war. The absence of gender differences in maximal skin conductivity could appear simply because women might perceive war scenes as disturbing, and men may perceive these as rather exciting. Resolving this question is difficult, as research examining female psychological adaptations to war is severely lacking (Scalise Sugiyama, 2014). Thus, the nature of similar EDA results could be a product of contrasting emotional reactions that are unable to be distinguished by our data collection methods.

Furthermore, our experiment was based exclusively on visual perceptions of war and sports. We speculate that certain acoustic cues, like loud battle cries, might increase aggression and group cohesion. But, as far as we are aware, this issue has never been investigated. For instance, a supportive audience impacts physiological variables in athletes (e.g., arousal, cardiac performance, Jones et al., 2007) and, at least under certain circumstances, can positively influence the performance of these athletes (Epting et al., 2011; Strauss & MacMahon, 2014). Male cooperation is further influenced by certain components of male sweat (Huoviala & Rantala 2013); thus, involvement of olfactory cues might also contribute to more precise results. In summary, the influence of acoustic and olfactory cues on physiology deserves future attention.

Collective competition against outgroups increases aggression more than individual competition, and ingroup cooperation is enhanced by testosterone, particularly when facing an outgroup threat (Muñoz-Reyes et al., 2020). Testosterone modulates skin conductivity, particularly in men with a history of partner violence (Romero-Martínez et al., 2013). Simultaneous measuring testosterone and aggression proneness in the future may be an additional avenue that may provide more sensitive data.

We predicted that women would show greater excitement and less militant attitudes toward war, relative to team sports, because women are more responsive to threat signals than men (McDonald et al., 2012; McClure et al., 2004). In line with this prediction, women showed significantly greater maximal skin conductivity when primed with war (relative to the control condition), although this difference did not reach statistical significance. Maximal skin conductivity in the war condition was similar between men and women. However, women showed no statistical difference between the war and control conditions. We consider these results as a non-significant tendency towards avoidance behaviour, as the reproductive costs for women during war are greater than those for men (McDonald et al., 2012; Thornhill & Palmer, 2000). Women showed lower skin conductivity than men when viewing the sport video, probably because they reported lower preferences for sports than men (Balish et al., 2016; Deaner et al., 2012). Unexpectedly, attitudes toward war were somewhat higher in women compared to men. Because Chang et al. (2011) did not compare militant attitudes between men and women, we are unable to compare these results with the existing literature. Given that women have not historically been involved in active military service and are less supportive of war than men (Pew Research Center, 2013; Torgler, 2003; Wilcox et al., 1996), these results are quite surprising.

Conclusions

To conclude, our results provide no statistical support for the idea that sports are a substitute for war via differences in skin conductivity and attitudes in a sample of Slovak participants. Neither physiological evidence nor psychological evidence was found to support the MWH. Thus, we cannot reject alternative, non-biological explanations for the evolution of warfare (i.e., cultural evolution, Henriques et al., 2019). Our study, however, is only an indirect test of the male warrior hypothesis, so our results do not allow us to unequivocally support or reject the MWH. The results of our study are preliminary, and we believe they will stimulate further research on this topic using similar approach. We also believe that future research may benefit from the inclusion of acoustic, olfactory or tactile cues to further test the MWH.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40750-022-00186-8.

Acknowledgements We would like to thank Professor Mark van Vugt, the Editor and two anonymous referees for their critical comments on an earlier draft of the MS. PP was partly funded by VEGA no. 1/0286/2020.

Data Availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of Interest The authors have no conflicts of interest to declare.

References

Adam, M. T., Krämer, J., & Weinhardt, C. (2012). Excitement up! Price down! Measuring emotions in Dutch auctions. *International Journal of Electronic Commerce*, 17(2), 7–40. https://doi.org/10.2753/JEC1086-4415170201

Balish, S. M., Deaner, R. O., Rainham, D., & Blanchard, C. (2016). Sex differences in sport remain when accounting for countries' gender inequality. *Cross-Cultural Research*, 50(5), 395–414. https://doi.org/10.1177/1069397116665815

Bechara, A., & Damasio, A. R. (2005). The somatic marker hypothesis: A neural theory of economic decision. *Games and Economic Behavior*, 52(2), 336–372. https://doi.org/10.1016/j.geb.2004.06.010

BIOPAC. EDA electrodes. (Accessed: Aug. 1 (2020a). [Online]. Available at: https://www.biopac.com/product/eda-electrodes/?attribute_pa_size=disp-eda-electrode-100pk

BIOPAC. EDA Introductory Guide. (Accessed: Aug. 1 (2020b). [Online]. Available: https://www.biopac.com/wp-content/uploads/EDA-Guide.pdf

Boucsein, W. (2012). Principles of electrodermal phenomena. In W. Boucsein (Ed.), *Electrodermal activity* (pp. 1–86). Boston, MA: Springer. https://doi.org/10.1007/978-1-4614-1126-0_1

Bowles, S. (2009). Did warfare among ancestral hunter–gatherer groups affect the evolution of human social behaviors. *Science*, 324(5932), 1293–1298. https://doi.org/10.1126/science.1168112

Chagnon, N. A. (1988). Life histories, blood revenge, and warfare in a tribal population. *Science*, 239(4843), 985–992. https://doi.org/10.1126/science.239.4843.985

Chang, L., Lu, H. J., Li, H., & Li, T. (2011). The face that launched a thousand ships: The mating-warring association in men. *Personality and Social Psychology Bulletin*, 37(7), 976–984. https://doi.org/10.1177/0146167211402216

Crofoot, M. C., & Wrangham, R. W. (2010). Intergroup aggression in primates and humans: the case for a unified theory. In P. M. Kappeler, & J. B. Silk (Eds.), *Mind the gap* (pp. 171–195). Berlin: Springer

Dawson, M. E., Schell, A. M., & Filion, D. L. (2007). The electrodermal system. In: J.T. Cacioppo, L.G. Tassinary, and G.G. Berntson (eds.), *Handbook of Psychophysiology*, (pp. 159–181 and 200–223, 3rd ed.). Cambridge: Cambridge University Press, New York

Deaner, R. O., Geary, D. C., Puts, D. A., Ham, S. A., Kruger, J., Fles, E. … Grandis, T. (2012). A sex difference in the predisposition for physical competition: males play sports much more than females even in the contemporary U.S. *PLoS ONE*, 7(11), e49168. https://doi.org/10.1371/journal.pone.0049168

Epting, L. K., Riggs, K. N., Knowles, J. D., & Hanky, J. J. (2011). Cheers vs. jeers: effects of audience feedback on individual athletic performance. *North American Journal of Psychology*, 13(2), 299–331

Escasa, M., Gray, P. B., & Patton, J. Q. (2010). Male traits associated with attractiveness in Conambo, Ecuador. *Evolution and Human Behavior*, 31(3), 193–200. https://doi.org/10.1016/j.evolhumbehav.2009.09.008

Faurie, C., Pontier, D., & Raymond, M. (2004). Student athletes claim to have more sexual partners than other students. *Evolution & Human Behavior*, 25(1), 1–8. https://doi.org/10.1016/S1090-5138(03)00064-3

FIFA (2015). 2014 FIFA World Cup ™ reached 3.2 billion viewers, one billion watched final. Retrieved from FIFA website: 2014 FIFA World Cup ™ available at: https://www.fifa.com/worldcup/news/2014-fifa-world-cuptm-reached-3-2-billion-viewers-one-billion-watched--2745519

Furley, P. (2019). What modern sports competitions can tell us about human nature. *Perspectives on Psychological Science*, 14(2), 138–155. https://doi.org/10.1177/1745691618794912

Geary, D. C. (1998). *Male, female: The evolution of human sex differences*. Washington, DC: American Psychological Association.

Glowacki, L., & Wrangham, R. W. (2013). The role of rewards in motivating participation in simple warfare. *Human Nature*, 24(4), 444–460. https://doi.org/10.1007/s12110-013-9178-8

Glowacki, L., & Wrangham, R. (2015). Warfare and reproductive success in a tribal population. *Proceedings of the National Academy of Sciences*, *112*(2), 348–353. https://doi.org/10.1073/pnas.1412287112

Greem, P., & MacLeod, C. J. (2016). SIMR: an R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution*, 7, 493–498. https://doi.org/10.1111/2041-210X.12504

Hames, R. (2020). Cultural and reproductive success and the causes of war: A Yanomamö perspective. *Evolution and Human Behavior*, 41(3), 183–187. https://doi.org/10.1016/j.evolhumbehav.2020.02.008

Henriques, G. J., Simon, B., Ispolatov, Y., & Doebeli, M. (2019). Acculturation drives the evolution of intergroup conflict. *Proceedings of the National Academy of Sciences*, *116*(28), 14089–14097. https://doi.org/10.1073/pnas.1810404116

Holm, S. K., Kaakinen, J. K., Forsström, S., & Surakka, V. (2021). Self-reported playing preferences resonate with emotion-related physiological reactions during playing and watching of first-person shooter videogames. *International Journal of Human-Computer Studies*, 155, 102690. https://doi.org/10.1016/j.ijhcs.2021.102690

Huoviala, P., & Rantala, M. J. (2013). A putative human pheromone, androstadienone, increases cooperation between men. *PloS One*, 8(5), e62499. https://doi.org/10.1371/journal.pone

Ji, T., Tybur, J. M., & van Vugt, M. (2021). Gendered outgroup prejudice: An evolutionary threat management perspective on anti-immigrant bias. *Group Processes & Intergroup Relations*, 24(1), 177–192. https://doi.org/10.1177/1368430219882489

Jones, M. V., Bray, S. R., & Lavallee, D. (2007). All the world's a stage: Impact of an audience on sport performers. In S. Jowett, & D. Lavallee (Eds.), *Social Psychology in Sport* (pp. 103–113). Champaign, IL: Human Kinetics

Kołodziej, M., Tarnowski, P., Majkowski, A., & Rak, R. (2019). Electrodermal activity measurements for detection of emotional arousal. *Bulletin of the Polish Academy of Sciences, Technical Sciences*, 67(4), 813–826. https://doi.org/10.24425/bpasts.2019.130190

Kreibig, S. D. (2010). Autonomic nervous system activity in emotion: a review. *Biological Psychology*, 84(3), 394–421. https://doi.org/10.1016/j.biopsycho.2010.03.010

Lahr, M. M., Rivera, F., Power, R. K., Mounier, A., Copsey, B., et al. (2016). Inter-group violence among early Holocene hunter-gatherers of West Turkana, Kenya. *Nature*, 529(7586), 394–398. https://doi.org/10.1038/nature16477

Lenth, R. V. (2016). Least-Squares Means: The R Package lsmeans. *Journal of Statistical Software*, 69(1), 1–33. https://doi.org/10.18637/jss.v069.i01

Livingstone Smith, D. (2007). *The most dangerous animal: Human nature and the origins of war*. New York:St. Martin's Press

Lizotte, M. K. (2015). Gender differences in support for torture. *Journal of Conflict Resolution*, 61(4), 772–787. https://doi.org/10.1177/0022002715595698

Lombardo, M. P. (2012). On the evolution of sport. *Evolutionary Psychology*, 10(1), 1–28. https://doi.org/10.1177/147470491201000101

Macfarlan, S. J., Walker, R. S., Flinn, M. V., & Chagnon, N. A. (2014). Lethal coalitionary aggression and long-term alliance formation among Yanomamö men. *Proceedings of the National Academy of Sciences U. S. A., 111*(47), 16662–16669. https://doi.org/10.1073/pnas.1418639111

Majolo, B. (2019). Warfare in an evolutionary perspective. *Evolutionary Anthropology: Issues, News, and Reviews*, 28(6), 321–331. https://doi.org/10.1002/evan.21806

Manson, J. H., Wrangham, R. W., Boone, J. L., Chapais, B., Dunbar, R. I. M., Ember, C. R., Irons, W., et al. (1991). Intergroup aggression in chimpanzees and humans [and comments and replies]. *Current Anthropology*, 32(4), 369–390. https://doi.org/10.1007/s12110-012-9132-1

McClure, E. B., Monk, C. S., Nelson, E. E., Zarahn, E., Leibenluft, E., Bilder, R. M., et al. (2004). A developmental examination of gender differences in brain engagement during evaluation of threat. *Biological Psychiatry*, 55(11), 1047–1055. https://doi.org/10.1016/j.biopsych.2004.02.013

McDonald, M. M., Navarrete, C. D., & Van Vugt, M. (2012). Evolution and the psychology of intergroup conflict: the male warrior hypothesis. *Philosophical Transactions of the Royal Society of London, Ser. B: Biological Sciences*, 367(1589), 670–679. https://doi.org/10.1098/rstb.2011.0301

Miller, K. E., Sabo, D. F., Farrell, M. P., Barnes, G. M., & Melnick, M. J. (1998). Athletic participation and sexual behavior in adolescents: The different worlds of boys and girls. *Journal of Health and Social Behavior*, 39(2), 108–123

Muñoz-Reyes, J. A., Polo, P., Valenzuela, N., Pavez, P., Ramírez-Herrera, O., Figueroa, et al. (2020). The Male Warrior Hypothesis: testosterone-related cooperation and aggression in the context of Intergroup Conflict. *Scientific Reports*, 10(1), 1–12. https://doi.org/10.1038/s41598-019-57259-0

Pew Research Center (2013). Continued support for U.S. drone strikes. Retrieved from http://www.people-press.org/files/legacypdf/2-11-13%20Drones%20Release.pdf

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/
Ramirez, A. V., Hornero, G., Royo, D., Aguilar, A., & Casas, O. (2020). Assessment of emotional states through physiological signals and its application in music therapy for disabled people. *IEEE Access: Practical Innovations, Open Solutions*, 8, 127659–127671. https://doi.org/10.1109/ACCESS.2020.3008269
Ravaja, N., Saari, T., Salminen, M., Laarni, J., & Kallinen, K. (2006). Phasic emotional reactions to video game events: A psychophysiological investigation. *Media Psychology*, 8(4), 343–367. https://doi.org/10.1207/s1532785xmep0804_2
Ravaja, N., Turpeinen, M., Saari, T., Puttonen, S., & Keltikangas-Järvinen, L. (2008). The psychophysiology of James Bond: Phasic emotional responses to violent video game events. *Emotion*, 8(1), 114–120. https://doi.org/10.1037/1528-3542.8.1.114
Romero-Martínez, A., Lila, M., Williams, R. K., González-Bono, E., & Moya-Albiol, L. (2013). Skin conductance rises in preparation and recovery to psychosocial stress and its relationship with impulsivity and testosterone in intimate partner violence perpetrators. *International Journal of Psychophysiology*, 90(3), 329–333. https://doi.org/10.1016/j.ijpsycho.2013.10.003
Scalise Sugiyama, M. (2014). Fitness costs of warfare for women. *Human Nature*, 25(4), 476–495. https://doi.org/10.1007/s12110-014-9216-1
Scalise Sugiyama, M., Mendoza, M., & Sugiyama, L. (2020). War games: Intergroup coalitional play fighting as a means of comparative coalition formidability assessment. *Evolutionary Behavioral Sciences*, 15(2), 91–110. https://doi.org/10.1037/ebs0000251
Schulte-Hostedde, A. I., Eys, M. A., & Johnson, K. (2008). Female mate choice is influenced by male sport participation. *Evolutionary Psychology*, 6(1), 113–124. https://doi.org/10.1177/147470490800600113
Schwarz, A., Mertens, L., Simons, M., Spook, J. E., Thompson, D., Cardon, G., et al. (2019). Which game narratives do adolescents of different gameplay and sociodemographic backgrounds prefer? a mixed-methods analysis. *Games for Health Journal*, 8(3), 195–204. https://doi.org/10.1089/g4h.2017.0178
Shavers, T., Baghurst, T., & Finkelstein, M. (2015). The influence of social status and power on the sexual behavior of male collegiate football athletes. *Journal for the Study of Sports and Athletes in Education*, 9(2), 86–101. https://doi.org/10.1179/1935739715Z.00000000037
Strauss, B., & MacMahon, C. (2014). Audience influences on athlete performances. In A. Papaioannou, & D. Hackfort (Eds.), *Routledge Companion to Sport and Exercise Psychology. Global Perspectives and Fundamental Concepts* (pp. 213–216). New York, NY: Routledge
Sulikowski, D., & Burke, D. (2014). Threat is in the sex of the beholder: men find weapons faster than do women. *Evolutionary Psychology*, 12(5), 913–931. https://doi.org/10.1177/147470491401200505
Thirer, J., & Wright, S. D. (1985). Sports and social status for adolescent males and females. *Sociology of Sport Journal*, 2(2), 164–171. https://doi.org/10.1123/ssj.2.2.164
Thornhill, R., & Palmer, C. T. (2000). *A natural history of rape: Biological bases of sexual coercion*. Cambridge, MA: The MIT press
TIBCO Software Inc (2017). Statistica (data analysis software system), version 13. http://statistica.io
Torgler, B. (2003). Why do people go to war? *Defence and Peace Economics*, 14(4), 261–280. https://doi.org/10.1080/10242690302929
van Vugt, M., Cremer, D. D., & Janssen, D. P. (2007). Gender differences in cooperation and competition: The male-warrior hypothesis. *Psychological Science*, 18(1), 19–23. https://doi.org/10.1111/j.1467-9280.2007.01842.x
Wilcox, C., Hewitt, L., & Allsop, D. (1996). The gender gap in attitudes toward the Gulf War: A cross-national perspective. *Journal of Peace Research*, 33(1), 67–82. https://doi.org/10.1177/0022343396033001005
Wilson, M. L., & Wrangham, R. W. (2003). Intergroup relations in chimpanzees. *Annual Review of Anthropology*, 32(1), 363–392. https://doi.org/10.1146/annurev.anthro.32.061002.120046
Winegard, B., & Deaner, R. O. (2010). The evolutionary significance of Red Sox Nation: Sport fandom as a by-product of coalitional psychology. *Evolutionary Psychology*, 8(3), 432–446. https://doi.org/10.1177/147470491000800310
Wu, X. J., Schepartz, L. A., Liu, W., & Trinkaus, E. (2011). Antemortem trauma and survival in the late middle Pleistocene human cranium from Maba, South China. *Proceedings of the National Academy of Sciences USA*, 108 (49), 19558–19562. https://doi.org/10.1073/pnas.1117113108
Wu, X., & Trinkaus, E. (2015). Neurocranial trauma in the late archaic human remains from Xujiayao, northern China. *International Journal of Osteoarchaeology*, 25(2), 245–252. https://doi.org/10.1002/oa.2283

Authors and Affiliations

Marián Hosťovecký[1] · Jan Riegert[2] · Adam Pazda[3] · Pavol Prokop[4,5]

✉ Pavol Prokop
pavol.prokop@savba.sk

Marián Hosťovecký
marian.hostovecky@centrum.sk

Jan Riegert
honza@riegert.cz

Adam Pazda
apazda@gmail.com

1 Department of Applied of Informatics, Faculty of Natural Sciences, University of Ss. Cyril and Methodius in Trnava, Nám. J. Herdu 2, 917 01 Trnava, Slovakia

2 Department of Zoology, Faculty of Science, University of South Bohemia, Branišovská 1760, 370 05 České Budějovice, Czech Republic

3 Department of Psychology, University of South Carolina Aiken, 471 Univ Pkwy, 29801 Aiken, SC, USA

4 Department of Environmental Ecology and Landscape Management, Faculty of Natural Sciences, Comenius University, Ilkovičova 6, 842 15 Bratislava, Slovakia

5 Institute of Zoology, Slovak Academy of Sciences, Dúbravská cesta 9, 845 06 Bratislava, Slovakia