The association between harm avoidance personality traits and self-reported concussion history in South African rugby union players

Sarah Mc Fie
Division of Exercise Science and Sports Medicine, Department of Human Biology, Faculty of Health Science, University of Cape Town, Cape Town, South Africa

Shameemah Abrahams
Division of Exercise Science and Sports Medicine, Department of Human Biology, Faculty of Health Science, University of Cape Town, Cape Town, South Africa

Jon Patricios
Morningside Sports Medicine Clinic, Johannesburg, South Africa
Section of Sports Medicine, University of Pretoria, Pretoria, South Africa
Department of Emergency Medicine, University of the Witwatersrand, Johannesburg, South Africa

Jason Suter
Sports Science Sports and Exercise Medicine Clinic, Cape Town, South Africa

Michael Posthumus
Division of Exercise Science and Sports Medicine, Department of Human Biology, Faculty of Health Science, University of Cape Town, Cape Town, South Africa

Alison V. September
Division of Exercise Science and Sports Medicine, Department of Human Biology, Faculty of Health Science, University of Cape Town, Cape Town, South Africa

Abstract

Objectives: Personality traits have been proposed to affect the risk of sports concussion, but evidence is limited. Cloninger's Tridimensional Personality Questionnaire (TPQ) measures novelty seeking, harm avoidance (HA), and reward dependence traits. The aim of this study was to investigate the relationship between TPQ scores and concussion history in rugby union players.

Design: Cross-sectional study

Methods: Rugby players from high schools, senior amateur clubs, and professional teams provided a self-reported concussion history and completed the TPQ. Participants reporting no previous concussions formed the control group, while participants reporting concussion formed the case group. A one-way analysis of

covariance, with age as a covariate, was used to examine the differences in TPQ scores between groups.

Results: Of the 309 participants, 54% reported a minimum of one concussion (junior:47%; amateur:52%; professional:72%). HA scores were significantly higher in junior players without a history of concussion compared to cases (p=0.006). Specifically, the junior control group had higher "anticipatory worry" (p=0.009) and "fear of uncertainty" (p=0.008). In contrast, the professional control group had lower HA scores than cases (p=0.009), while the amateur cohort displayed no differences between control and case groups.

Conclusions: This study identified a novel association between HA and concussion in rugby players, adding evidence to the role of personality in a multifactorial risk-model of concussion. The findings suggest that lower HA may lead to increased dangerous play in youth rugby, influencing concussion susceptibility. Contrasting associations in the professional cohort suggest further research is required to understand the role of personality in concussion.

Key words: brain concussion, rugby, personality, temperament, athletic injuries.

Introduction

Concussion is defined as "a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces".[1] It is estimated that 1.6 – 3.8 million concussions occur annually in the USA.[2] A history of multiple concussions is suggested to result in an increased risk of developing long-term neurological and psychological complaints.[3] The incidence, time lost from participation, and the potential long-term effects of concussion, highlight the importance of identifying risk factors and understanding the underlying biology of sport-related concussion.

Individual personality traits have been associated with an increased risk of acute sports injuries.[4–6] More specifically; impulsivity, neuroticism, anxiety, and extraversion have been found to correlate with overall injury risk in sport.[4–6] Ice-hockey players who claimed that they play in order get rid of excess aggression, were found to be four times more likely to be concussed.[7]

Rugby Union, hereafter referred to as rugby, is a game with frequent high impact collisions and therefore associated with a relatively high concussion profile compared to other team sports.[8] It has been proposed that the attitude and behaviour of rugby players can affect their risk of injury.[9] Specifically, increased concussion rates were noted in rugby players with higher impulsivity scores.[10] The majority of concussions in rugby occur during player-player contact.[11] It may be possible that personality, or a certain behaviour profile, may impact on how an individual player approaches and engages in contact situations, and thereby modify their concussion susceptibility. For example, in soccer, players with higher extraversion scores were more likely to head the ball.[12]

Cloninger et al. developed the Tridimensional Personality Questionnaire (TPQ), aimed at computing three facets of an individual's temperament, namely novelty seeking (NS), harm avoidance (HA), and reward dependence (RD).[13] NS is defined as a "tendency toward frequent exploratory activity and intense excitement in response to novel stimuli" and is indicative of risk-taking and impulsive behaviour.[13] HA is the "tendency to avoid aversive situations" and is described as a measure of the perceived risk and anxiety of a given situation, whereas RD is "a tendency to respond intensely to signals of reward".[13] It may therefore be possible for these personality measures to indirectly quantify behaviours such as risk taking, impulsivity, and perceived risk that could possibly affect concussion susceptibility.

The aim of this study was to explore the relationship between personality scores, as measured by Cloninger's TPQ,[13] with concussion history in rugby players.

Methods

Whilst adhering to the Declaration of Helsinki ethical guidelines, and following approval from the Human Research Ethics Committee of the University of Cape Town, the Western Cape Education Department, and relevant school administrators, schools, senior community-level amateur clubs, and senior professional teams were approached to participate in the study between 2013 and 2015. A total of 487 apparently healthy active male rugby players volunteered to participate in the study, and completed the consent and/or assent forms, from four of the eight high schools ("junior": n=248), all three senior community-level amateur clubs ("amateur": n=170), and the two professional teams ("professional": n=69). Participants were then required to complete the study questionnaire containing: (i) personal details, medical, and sporting history questionnaire, (ii) a concussion history questionnaire, and (iii) Cloninger's TPQ. For the adult participants (amateur and professional) the consent form and study questionnaire were completed in a single session. For the junior participants, consent was first required from both parent and junior before the study questionnaire was completed at a subsequent time point. Junior participants who had completed consent and assent forms, but did not submit the study questionnaire were excluded (n=70).

Participants previously diagnosed with meningitis (n=6), epilepsy (n=3), stroke (n=2), mood or psychiatric disorders (n=2), or had sustained a non-rugby related concussion (n=24). Participants without a self-reported English language comprehension did not complete the TPQ and were excluded from the study (all levels: n=17; junior: n=17; amateur: n=0; professional: n=0). Within the TPQ, there were two validation items (blank questions with true and false answer boxes) to test

for carelessness and inaccuracy of responses. If one, or both, of these validation items were answered the participant was removed from the study (all levels: n=54; junior: n=30; amateur: n=14; professional: n=10). A total of 309 participants were included in the study (junior: n=107, age: 16.5 ± 1.3 years; amateur: n=145, age: 21.6 ± 4.4 years; professional: n=57, age: 24.5 ± 3.6 years).

All participants were enrolled using identical methods, with control and case groups assigned after recruitment based on self-reported concussion history. We defined concussions according to the Zurich Consensus statement[1] as a direct, or indirect, blow to the head during a rugby-related activity, that resulted in a set of clinical signs and symptoms that may or may not have involved loss of consciousness. The self-reported concussion history questionnaire required participants to provide details of their four most recent concussions. Specifically, information was collected on the date and mechanism of concussion injury, whether the concussion was diagnosed by a medical professional, the occupation of that medical professional (medical doctor, physiotherapist, nurse, paramedic), the symptoms experienced, and the duration of symptoms. Participants selected the relevant symptoms from a concussion symptom list, which was constructed from the symptom evaluation section of the Sports Concussion Assessment Tool (3rd edition).[14]

“Diagnosed concussions” were defined as concussions reportedly diagnosed by a medical professional (doctor, physiotherapist, nurse, paramedic) and qualified by one or more concussion symptoms. “Suspected concussions” were defined as concussions that were not diagnosed by medical personnel, but were described in conjunction with concussion symptoms.

The control group included all individuals reporting no suspected or diagnosed concussions (n=142), while the case group included all participants with a minimum

of one suspected or diagnosed concussion (n=167). The case subgroup, “case (diagnosed)”, only included participants with one or more diagnosed concussions (n=134), thus excluding suspected concussions.

Participants were asked to disclose any current or previously diagnosed medical conditions and describe details of their lifetime rugby and sporting participation, including the total years of participation, highest level of play, and playing position (if applicable).

Cloninger’s 96-item true/false, self-administered TPQ[13] comprises of 33 NS, 34 HA, and 29 RD questions, with zero or one scored for each question. Within each of the three dimensions (NS, HA and RD) are four subscales, as described in Supplementary Table S1. Higher scores indicate increased HA, NS, and RD behaviors. For example, an individual with a high HA score would be more reluctant to partake in risky or aversive activities compared to someone with a low HA score. In the case of incomplete questionnaires, the sections that were completed were included, while the incomplete sections were excluded from the analysis. The NS section was completed by 92% (NS1: 97%; NS2: 96% NS3: 98%; NS4: 96%), the HA section by 94% (HA1: 97%; HA2: 98%; HA3: 99%; HA4: 99%), and the RD section by 94% (RD1: 98%; RD2: 97%; RD3: 97%; RD4: 99%) of included participants.

The Shapiro Wilk test was used to test whether the data sets were normally distributed. A one-way analysis of variance (ANOVA), with Tukeys *post-hoc* test, was used to observe differences in parametric participant characteristic data, while a Mann Whitney U test was used to investigate differences in non-parametric participant characteristic data between groups. As a result of negligible differences between ANOVA and Mann Whitney U results, all data was represented as being parametric with the ANOVA results displayed.

Due to the possible effect of age on personality traits,[15] a one-way analysis of covariance (ANCOVA), with age as a covariate, was used to examine the differences in TPQ scores between the control and case groups. If significant differences or trends were found between groups in any of the three TPQ dimensions (NS, HA, or RD), additional analysis was completed on the four subscales of that dimension. In addition, a Fisher's exact test was used to observe differences in the distribution of TPQ dimension scores between groups. The participants were subdivided into age cohorts for analysis. Furthermore, because of differences in the level of competition between senior amateur and professional adult players, professional players were analysed as a separate cohort. P values less than 0.05 were accepted as statistically significant. All statistical analysis was done using STATISTICA (Version 11, StatSoft Inc., Tulsa, OK, USA).

The Human Research Ethics Committee of the University of Cape Town granted ethical approval for this study. The study adhered to the Declaration of Helsinki ethical guidelines. The Western Cape Education Department and relevant school administrators gave permission to conduct research at schools. All participants gave written informed consent and in the case of minors, written informed assent from the minor and informed consent from a parent or legal guardian was obtained.

Results

Fifty-four percent of participants (n=167) reported a previous suspected or diagnosed concussion (junior: 47%, n=50; amateur: 52%, n=76; professional: 72%, n=41). Forty-three per cent (n=134) of the participants reported at least one medically diagnosed concussion (junior: 35%, n=37; amateur: 41%, n=60; professional: 65%, n=37). Twenty-six per cent (n=81) of participants reported a single suspected or diagnosed concussion (junior: 32%, n=34; amateur: 22%, n=32; professional: 26%, n=15), while 28% (n=87) reported two or more concussions (junior: 16%, n=17;

amateur: 30%, n=44; professional: 46%, n=26). A medical professional reportedly diagnosed 71% of all concussion events (junior: 73%, n=58; amateur: 70%, n=101; professional: 70%, n=56). The average time since the most recent concussion was 2.7 ± 2.6 years ago (n=150) (junior: 1.3 ± 1.5 years, n=43; amateur: 3.2 ± 2.9 years, n=71; professional: 3.3 ± 2.5, n=36) and 3.5 ± 3.3 years ago (n=255) for all recorded concussion events (junior: 1.5 ± 1.6 years, n=62; amateur: 4.0 ± 3.3, n=127; professional: 4.2 ± 3.3, n=62).

The control and case groups within the junior, amateur, and professional cohorts were similar in age (junior: p=0.389; amateur: p=0.679; professional: p=0.661), height (junior: p=0.116; amateur: p=0.250; professional: p=0.229), weight (junior: p=0.093; amateur: p=0.824; professional: p=0.296), BMI (junior: p=0.129; amateur: p=0.595; professional: p=0.705), and years of rugby exposure (junior: p=0.897; amateur: p=0.588; professional: p=0.091) (Supplementary Table 2).

The amateur group (NS: 16.7 ± 5.2, n=137) had significantly higher NS scores than the professional (NS: 14.2 ± 5.4, n=52, p=0.006), but not junior (NS: 15.4 ± 4.3, n=96, p=0.299) group (Table 1). Of the NS subscales, the amateur cohort (NS3: 3.6 ± 1.9, n=144) had significantly higher NS3 (“extravagance”) scores than the junior (NS3: 2.5 ± 1.5, n=104, p<0.001) and professional (NS3: 2.7 ± 1.6, n=143, p=0.001) cohorts. The junior cohort (HA1: 3.6 ± 2.1, n=103) had significantly higher HA1 (“anticipatory worry”) scores than the amateur (HA1: 2.7 ± 2.0, n=141, p=0.002) and professional cohort (HA1: 2.8 ± 2.0, n=56, p=0.040). There were no statistical differences in RD between levels of play.

Table 1. The mean scores for the three Tridimensional Personality Questionnaire (TPQ) dimensions, novelty seeking (NS), harm avoidance (HA) and reward dependence (RD), for junior, senior amateur (amateur), and senior professional (professional) South African rugby players.

TPQ dimension	**Level of play**			
	Junior	**Amateur**	**Professional**	**p Value**
n	107	145	57	
NS	15.4 ± 4.3 (96)	16.7 ± 5.2 (137)[a]	14.2 ± 5.4 (52)[a]	**0.006**
NS1	4.4 ± 1.6 (106)	4.5 ± 1.5 (141)	4.0 ± 1.6 (54)	0.132
NS2	3.3 ± 1.8 (102)	3.4 ± 1.9 (140)	2.9 ± 2.1 (55)	0.327
NS3	2.5 ± 1.5 (104)[b]	3.6 ± 1.9 (144)[b,c]	2.7 ± 1.6 (56)[c]	**<0.001**
NS4	5.2 ± 2.0 (103)	5.3 ± 2.0 (140)	4.8 ± 2.0 (55)	0.252
HA	11.7 ± 5.8 (97)	10.1 ± 5.8 (137)	10.2 ± 5.5 (55)	0.087
HA1	3.6 ± 2.1 (103)[d,e]	2.7 ± 2.0 (141)[d]	2.8 ± 2.0 (56)[e]	0.002
HA2	2.6 ± 1.8 (102)	2.5 ± 1.9 (143)	2.7 ± 1.6 (57)	0.683
HA3	2.6 ± 2.1 (106)	2.2 ± 2.0 (144)	2.4 ± 1.9 (56)	0.254
HA4	3.1 ± 2.4 (105)	2.7 ± 2.4 (143)	2.2 ± 2.1 (57)	0.093
RD	18. ± 4.0 (99)	18.6 ± 4.1 (139)	18.5 ± 4.2 (53)	0.463

Data are expressed as the mean ± standard deviation with the number of participants (n) in parenthesis. Statistically significant differences ($p < 0.05$) between all levels of play are displayed in bold. HA1: anticipatory worry; HA2: fear of uncertainty; HA3: shyness/shyness with strangers; HA4: fatigability and asthenia; NS1: exploratory excitability; NS2: impulsiveness; NS3: extravagance; NS4: disorderliness. [a]The amateur group had significantly higher NS scores than the professional group ($p = 0.006$). NS3 was higher in the amateur compared to the [b]junior ($p < 0.001$) and [c]professional group ($p = 0.001$). The junior cohort had significantly higher HA1 scores than the [d]amateur ($p = 0.002$) and [e]professional cohort ($p = 0.040$).

In the junior cohort, the control group (13.2 ± 5.8, n=51) had significantly higher HA scores than the case (HA: 10.0 ± 5.4, n=46, p=0.006) and case (diagnosed) (HA: 9.6 ± 5.0, n=34, p=0.003) groups (Table 2). Furthermore, there was a lower percentage of control (8%, n=4) participants with HA scores less than six, compared to the case (24%, n=11, p=0.047) and case (diagnosed) (26%, n=9, p=0.030) groups, and a higher proportion of control participants with HA scores above 15 (35%, n=18) compared to the case (diagnosed) (12%, n=4, p=0.022) group (Figure 1a). Analysis of the HA subscales revealed that the control group (HA1: 4.1 ± 2.1, n=55; HA2: 3.1 ± 1.9, n=54) had higher HA1 (“anticipatory worry”) and HA2 (“fear of uncertainty”) than the junior case group (HA1: 3.0 ± 1.9, n=48, p=0.009; HA2: 2.1 ± 1.6, n=48, p=0.008) and case (diagnosed) subgroup (HA1: 2.8 ± 1.7, n=36, p=0.003; HA2: 1.9 ± 1.5, n= 35, p=0.003) (Table 2).

Table 2. The mean scores for the three Tridimensional Personality Questionnaire (TPQ) dimensions, novelty seeking (NS), harm avoidance (HA) and reward dependence (RD), for South African junior, senior amateur (amateur), and senior professional (professional) rugby players without a previous suspected or diagnosed concussion (control), with a minimum of one suspected or diagnosed concussion (case), and case participants with one or more diagnosed concussions (case diagnosed).

	Control	**Case**	**p Value[a]**	**Case (diagnosed)**	**p Value[b]**
Junior					
n	57	50		37	
NS	15.8 ± 4.5 (52)	15.1 ± 3.9 (44)	0.470	15.1 ± 3.8 (32)	0.512
HA	13.2 ± 5.8 (51)	10.0 ± 5.4 (46)	**0.006**	9.6 ± 5.0 (34)	**0.003**
HA1	4.1 ± 2.1 (55)	3.0 ± 1.9 (48)	**0.009**	2.8 ± 1.7 (36)	**0.003**
HA2	3.1 ± 1.9 (54)	2.1 ± 1.6 (48)	**0.008**	1.9 ± 1.5 (35)	**0.003**
HA3	2.9 ± 2.2 (56)	2.3 ± 2.0 (50)	0.064	2.3 ± 2.0 (37)	0.063
HA4	3.3 ± 2.3 (56)	2.8 ± 2.5 (49)	0.391	2.7 ± 2.4 (36)	0.300
RD	18.0 ± 3.9 (51)	17.9 ± 4.8 (48)	0.716	18.5 ± 4.8 (36)	0.815
Amateur					
n	69	76		60	
NS	16.5 ± 5.1 (63)	16.8 ± 5.2 (74)	0.765	17.1 ± 5.1 (58)	0.551
HA	9.6 ± 5.5 (64)	10.5 ± 6.2 (73)	0.327	10.8 ± 6.1 (57)	0.263
RD	18.9 ± 4.0 (66)	18.4 ± 4.2 (73)	0.501	19.1 ± 3.7 (58)	0.805
Professional					
n	16	41		37	
NS	13.3 ± 6.0 (16)	14.6 ± 5.2 (36)	0.383	14.5 ± 5.1 (33)	0.408
HA	7.3 ± 3.9 (16)	11.4 ± 5.6 (39)	**0.009**	11.4 ± 5.7 (36)	**0.011**
HA1	1.9 ± 1.3 (16)	3.2 ± 2.2 (40)	**0.029**	3.2 ± 2.2 (36)	**0.027**
HA2	2.9 ± 1.8 (16)	2.7 ± 1.6 (41)	0.641	2.5 ± 1.5 (37)	0.483
HA3	1.7 ± 1.4 (16)	2.8 ± 2.0 (40)	0.056	2.8 ± 2.0 (37)	0.060
HA4	0.8 ± 0.9 (16)	2.8 ± 2.2 (41)	**0.001**	2.8 ± 2.3 (37)	**0.001**
RD	17.4 ± 4.2 (14)	18.9 ± 4.1 (39)	0.247	19.2 ± 4.2 (36)	0.194

Data are expressed as the mean ± standard deviation with the number of participants (n) in parenthesis. Age-adjusted p values for [a]control versus case group and [b]control versus case (diagnosed) subgroup. Statistically significant differences ($p < 0.05$) between control and case groups are displayed in bold. HA1: anticipatory worry; HA2: fear of uncertainty; HA3: shyness/shyness with strangers; HA4: fatigability and asthenia.

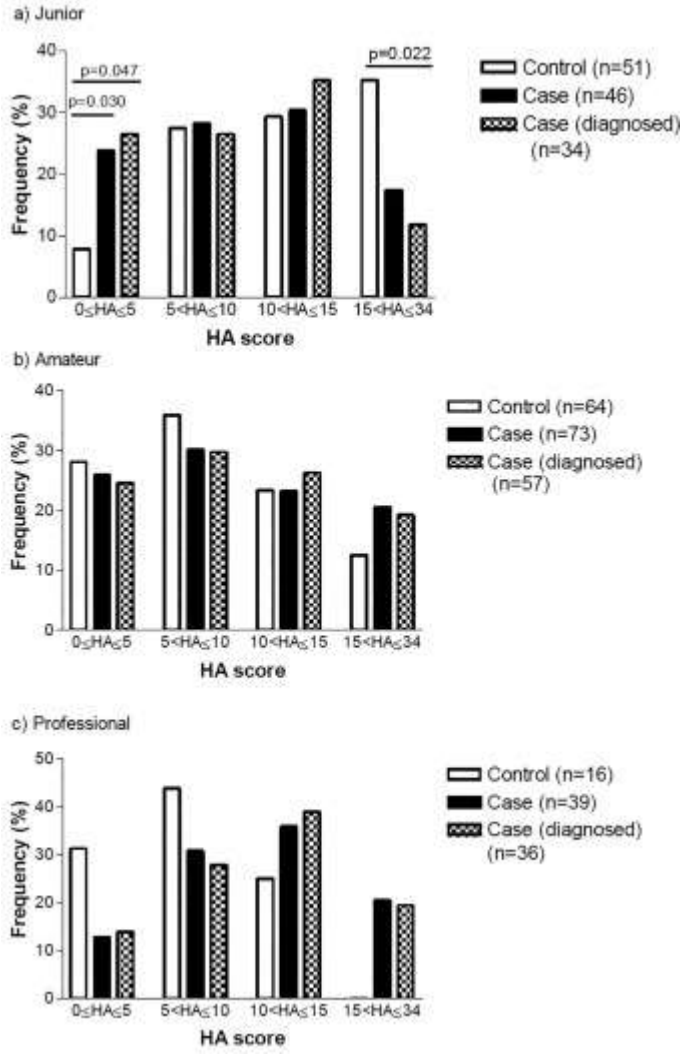

Fig. 1. The distribution of harm avoidance (HA) scores in a) junior, b) senior amateur, and c) professional players without a previous suspected or diagnosed concussion (control), with a minimum of one suspected or diagnosed concussion (case), and case participants with one or more diagnosed concussions (case diagnosed). a) There was a lower proportion of junior control (8%, n = 4) participants with total HA scores less or equal to five, compared to the junior case (24%, n = 11, p = 0.047) and case (diagnosed) (27%, n = 9, p = 0.030) groups. There was a higher proportion of junior control participants (35%, n = 18) with HA scores above 15 than the case (diagnosed) (12%, n = 4, p = 0.022) group.

There were no statistical differences in any of the TPQ dimension mean scores between case and control groups in the amateur cohort (Table 2).

In contrast to the junior cohort, HA was significantly lower in the professional control (HA: 7.3 ± 3.9, n=16) group than the case (HA: 11.4 ± 5.6, n=39, p=0.009) and case (diagnosed) (HA: 11.4 ± 5.7, n=36, p=0.011) groups. Specifically, the professional control (HA1: 1.9 ± 1.3, n=16; HA4: 0.8 ± 0.9, n=16) group had lower HA1

("anticipatory worry") and HA4 ("fatigability and asthenia") than the case (HA1: 3.2 ± 2.2, n=40, p=0.029; HA4: 2.8 ± 2.1, n=41, p=0.001) and case (diagnosed) (HA1: 3.2 ± 2.2, n=36, p=0.027; HA4: 2.8 ± 2.3, n=37, p=0.001) groups (Table 2). There were no significant differences in the proportional distribution of HA scores between control and case groups in the amateur or professional cohorts (Figure 1b and 1c).

Discussion

The main findings of this study were that junior rugby players with a history of concussion had significantly lower HA scores than players without a previous concussion, while conversely, the professional players with a history of concussion had higher HA scores than those without a concussion history.

Generally, an individual with low HA is characterised by being carefree, confident and optimistic, while an individual with high HA will be more cautious and anxious. Therefore, in this study, junior players with a history of concussion had higher measures of confidence and optimism in conjunction with lower levels of perceived risk and caution, compared to those without a history of concussion.

To date, only a few studies investigating the effect of personality traits on concussion or injury risk in rugby have been reported. Hollis et al. (2009) found that rugby players with high impulsivity scores had increased rates of concussion compared to those with medium or low scores.[10] While a study comparing anger and hostility traits observed no differences between injured and uninjured rugby players.[16]

A review of the influence of psychological factors on sports injuries concluded that although no single personality profile has consistently been associated with athlete injuries, there is an emergence of evidence linking a "readiness to take risks" to increased injury rates.[17] Decreased injury risk appraisal has consistently been shown

to result in increased risk-taking behaviour in sports and recreational activities[18] and has been associated with increased sports injury risk.[19,20] A study of adolescent soccer players found that lower levels of self-reported perceived injury risk resulted in a 3.8 to 7.9 fold greater rate of injury.[19] While a study of over 1400 adolescents found that higher self-reported risk taking behavior was associated with increased injury risk.[20]

HA scores are linked to risk taking decisions[21] and risky or dangerous behaviors outside of a sporting context.[22] Furthermore, high HA scores have also been associated with heightened physical pain perception.[23] To the best of the authors' knowledge there have been no published studies specifically investigating the relationship between HA and collision sports' injury risk. However, we can postulate that rugby players with lower HA scores, and thus decreased risk appraisal, may take greater risks and more readily approach contact situations. Individuals with high HA, on the other hand, may be more cautious going into contact, or avoid contact, thus reducing their exposure to possible concussion causing events.

Of the HA subscales, HA1 and HA2 showed an association with concussion. Low HA1 scores are indicative of uninhibited optimism and decreased anticipatory worry, while decreased HA2 is associated with increased confidence and a lower fear of uncertainty. Bandura et al. (1997) suggests that an over confidence or overestimation of ability can lead to athletes attempting more risky or dangerous behaviors without having sufficient skill, which can result in an increased chance of injury.[24]

Adolescence is a period synonymous with heightened impulsivity, risk-taking, and unintentional injury risk.[25] Two neural developmental processes are suggested to underlie this behavioural change.[26] Firstly, the development of the frontostriatal

reward circuits cause an increase in dopaminergic activity and novelty seeking tendencies.[26] Secondly, the incomplete maturation of the "cognitive control" systems of the prefrontal cortex limits the ability to adequately assess risk and control risk-taking behaviors.[26] Furthermore, adolescent rugby players may have less developed contact skill technique, which was suggested to affect concussion risk.[11] Therefore, adolescent rugby players may be particularly vulnerable to underestimating the associated injury risk and may more readily partake in risky or dangerous behaviour without having a sufficiently safe contact technique to avoid injury.

There were no associations between any of the TPQ traits and concussion history in the adult amateur players. Personality traits heavily influence the choice of recreational activities in adulthood.[27,28] Therefore, at the amateur level where rugby participation is less common and more of a personal preference, individuals with high HA may choose to avoid rugby and therefore could have been selected out of the cohort, which would reduce any possible associations between HA and concussion. In support, the amateur cohort had higher NS and lower HA scores, which is also consistent with previous studies of voluntary high-risk sports participants[27,28]

The professional cohort displayed paradoxical results to the junior cohort, with players with a history of concussion having higher HA scores. A possible mitigating factor in the association between risk taking and injury induction is the level of skill and belief in one's ability.[19,24] A technically skillful contact technique is considered an asset in reducing the risk of injury and concussion in rugby.[11,29] Therefore, risk-taking behaviours at the elite level may not be associated with the same level of injury risk as the amateur level due to a higher level of skill and execution. Furthermore, Bandura et al. (1997) suggests that increased perception of risk is linked to lower self-efficacy and heightened belief of failure, which may increase the risk of an adverse outcome or injury.[24] It may also be argued that the pressure to perform at

the elite level may override any personal preference to avoid contact or potentially harmful situations. However, a considerable limitation of this cohort was the low sample size, with only 16 players included in the control (without previous concussion) group. A larger sample size is required to investigate this effect further.

There were no significant differences in NS or RD scores between those with and without a history of concussion. NS is described to be indicative of risk-taking and impulsive behaviors.[13] Hollis et al. (2009) found an association between impulsivity and concussion risk in rugby players. In contrast, no association was seen between impulsivity (NS2) and concussion history in the present study. However, NS scores may only partially correlate with risk in a sporting context as previous studies have produced mixed results regarding the association between novelty or sensation seeking and risk taking behavior or injuries in athletes.[17] There is less supporting evidence in the scientific literature that RD traits could influence concussion risk. Therefore, the negative findings seen regarding RD in the current study were not altogether surprising.

Although this study highlighted a novel personality trait correlation with concussion, there were several limitations. The primary limitation was that concussion history was self-reported by participants. Self-reported concussions can be unreliable as the ability to recognize and report concussions may be influenced by a variety of external factors, including concussion knowledge, attitudes, perceptions, and age,[30] and may be subject to recall bias, possibly underestimating or overestimating the number of concussions. A study, assessing the reliability of professional American football athletes self-reported concussion history, deduced that the provided concussion history was moderately reliable[31], and therefore useful if the findings are interpreted with caution.

Small sample size was a further limitation. The number of junior participants not returning to complete the study questionnaire and the number of participants failing the validity checks in the TPQ significantly reduced the sample size. It is unknown whether these exclusions introduced a selection bias and therefore results need to be interpreted with caution. Future studies should implement a large-scale prospective design with strict injury surveillance and medical doctor diagnosed concussions. Additionally, the TPQ does not directly measure sport or rugby-specific personality traits and therefore further investigation is required to identify to what extent personality traits, such as HA, confer directly to risk-taking behaviors on the rugby field, and whether risky or dangerous behavior is contributing to the concussion mechanism.

Conclusion

This study provides a novel association between HA scores and concussion in rugby players. The findings promote implementation of interventions to educate youth rugby players on the risks of reckless, dangerous, or unsafe play. There is a need to develop an integrated perspective on sports injuries that takes into account, medical, behavioural, physiological, and biomechanical factors in order to effectively reduce injury rates.[32] This study provides new information on the role of personality in concussion risk that may add to an integrated risk model of concussion.

Practical implications

- The provisional results of this study implicate the role of personality and behavior in the susceptibility to sports concussion and further research is required.
- The findings suggest that personality traits influencing risk appraisal and risk-taking behaviour may modulate concussion risk in rugby, although the exact relationship still needs to be determined.

- The study suggests that education, highlighting the potential risks of reckless, dangerous, and unsafe play, may be useful in youth rugby.

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Competing interests

None.

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