The revised perceived academic impact tool (PAIT2)

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The revised perceived academic impact tool (PAIT2): A tool to assess academic dysfunction in university-aged student-athletes with sports-related concussion

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Abstract

Research acknowledges Sports-Related Concussion (SRC) is acutely deleterious to academic ability, but no tool has been validated to measure the effect of SRC on academic ability. The sutdy aimed to establish if the Revised Perceived Academic Impact Tool (PAIT2) is reliable and valid for assessing academic impairment following an SRC. Non-concussed, healthy student-athletes in higher education were recruited to the control group and completed the PAIT2 at day 0, 2, 4, 8, 14 and 19. The concussed group consisted of higher education student-athletes participating in rugby union. The concussed group completed the PAIT2 at baseline screening during pre-season, day 2, 4, 8 and 14 following an SRC and at return-to-play. The PAIT2 asks participants to rate their perceived ability on 23 academic tasks on a statement scored on a 0–6 Likert scale. Repeated measurements from the healthy group (n = 25) demonstrated PAIT2 has good internal validity ($\chi^2(25)$ = 2.128 and p = 0.712) and reliability (0.880 [95% CI: 0.785–0.941]). A change of 4.631 (80% CI) can be used to indicate if academic impairment is present following an SRC. PAIT2 identified 96% of concussed student-athletes with academic impairment at day 2, 92% at day 4, 85.71% at day 8 and 92% at day 14 and 19. PAIT2 has good reliability and internal validity for detecting those with academic impairment following SRC. The use of this tool may be of assistance to clinicians when managing student-athletes return to learn.

KEYWORDS
academic impact, neurocognition, return to learn, sports-related concussion

Highlights

- No previous studies have used an assessment tool to measure perceived academic ability during the acute phase of a Sports-Related Concussion (SRC). The Revised Perceived Academic Impairment Tool (PAIT2) may fill this void but has not been validated or its reliability established.

- The concussed group had significantly worse self-perceived academic performance at day 2, but not by day 4, indicating perceived academic ability recovers by 4 days following an SRC.
- The PAIT2 had good validity and reliability and was able to detect 96.00%, 92.00% and 85.71% of concussed student-athletes with academic impairment at day 2, 4, 8 and 14 days post-SRC.
- Other measures, such as academic time loss or the Immediate Post Concussion Test, were not superior for detecting academic impairment, but the use of this with PAIT2 was superior for ruling out academic impairment rather than just the PAIT2.

1 | INTRODUCTION

Studies investigating the acute effects of Sport-Related Concussion (SRC) on academic ability have reported concussion-related symptoms are associated with increased academic impairment (Baker et al., 2020; Ransom et al., 2015; Wasserman et al., 2016), academic time loss (Babcock et al., 2013; Glendon et al., 2021a) and a reduction in quality of life (Novak et al., 2016; Veliz et al., 2017). SRC causes neuronal stretching and metabolic changes resulting in an energy crisis and disruption in neurotransmission (Giza et al., 2014). Impaired neurotransmission results in failures of communication between brain networks when processing information, resulting in impaired cognitive function (Hristopulos et al., 2019). These acute effects of SRC may explain why studies have found academic impairment may exist in the acute phase, warranting an assessment method to assess for and track recovery of academic dysfunction following an SRC.

Previous studies have used questionnaires, recorded days missed from school or changes in grades to assess for academic dysfunction following an SRC. The Children's Exertional Effects Rating Scale (ChEERS) records symptom exacerbation after completing neurocognitive testing. It demonstrated good reliability in participants 5–18 years old when used within 21 days of SRC (Sady et al., 2019) and good discriminate validity for classifying those with high or low academic impairment in participants 11–18 years old when used within 4 weeks (Ransom et al., 2016). Other studies have recorded the number of school days missed due to academic impairment and reported greater academic time loss in concussed adolescent groups (Babcock et al., 2013; Russell et al., 2016). Academic grades have also been reported to decline over a 3-year period in adolescents who played rugby with or without a history of SRC compared to non-contact sport controls (Alexander et al., 2015).

Promising previous work by Wasserman et al. (2016) used a self-reported questionnaire to quantify academic impairment at 1 week and 1 month post-SRC in concussed participants compared to those that suffered a lower extremity injury. Participants with SRC reported greater academic impairment on the questionnaire, took longer to return to school and required more academic adjustments. A self-rated questionnaire to ascertain perceived academic ability may have clinical utility to quantify severity and enable repeated measures to track the recovery of academic impairment following an SRC. Studies have shown returning to academic activities and school too soon or too slowly is deleterious to recovery from SRC (Majerske et al., 2008; Ransom et al., 2015). Current clinical assessment batteries would benefit from the inclusion of a reliable and valid tool that assesses the severity of academic impairment, guide decisions on academic adjustment requirements, appropriate progression along the return to learn (RTL) protocol and eventually full RTL.

None of the aforementioned studies have assessed the academic impairment of collegiate student-athletes within the initial week following SRC or conducted repeated measures to track recovery. Only one study has reported academic time loss in collegiate aged student-athletes and reported a higher percentage of participants were able to RTL by 2–7 days if they exercised rather than physically rested (92% vs. 53%) (Howell et al., 2020). The authors have previously published research in this field using an adapted version of the questionnaire used by Wasserman et al. (2016), the Perceived Academic Impact Tool (PAIT). The original PAIT was slightly adapted from the questionnaire used by Wasserman et al. (2016) to suit UK university-age student-athletes. Greater PAIT impairment was associated with VOM dysfunction at 2, 4, 8 and 14 days post-SRC (Glendon et al., 2021b), but whole cohort PAIT scores were not affected post-SRC despite significant time loss in contact academic activities at 2, 4, 8 and 14 days post-SRC and non-contact time loss at 2 and 4 days (Glendon et al., 2021a). Furthermore, significant improvements in perceived academic ability beyond baseline scores were found (Glendon et al., 2021a), which may have been due to participants rating themselves on a numbered scale and exaggerating their recovery. Therefore, the original PAIT by Glendon et al. (2021a, 2021b) was modified to enhance the reliability of the tool.

Several adaptations were made to PAIT based on results from previous studies, feedback and discussion of the authors to develop the revised PAIT (PAIT2) questionnaire. Firstly, PAIT2 has a worded Likert scale rather than the numbered Likert scale used in the original. Several of the questions in the original PAIT were negatively leading, which can form a bias and adversely affect performance/score/outcomes (Allen, 2017). To reduce this risk of bias altering participants' responses, questions were rewritten removing any negative language. For example, the statement; 'I have trouble remembering what I learned last week', was altered to neutral language; 'what percentage do these statements describe you, I remember what I learnt last week; 0, 15, 30, 50, 65, 80 or 100%?' Where questions were repetitive (I don't get distracted when doing university work and I'm able to stay on task), they were combined and questions relating to the use of screens were included to reflect studies reporting use of screens affecting concussion recovery (Macnow et al., 2021). The PAIT2 questionnaire has questions relating to understanding verbal or written information and responding to this, ability to concentrate, problem solving, studying at the same pace as peers, short- and long-term memory, cognitive fatigue, ability to tolerate noisy or busy environments and use screens. Further research is required to evaluate the reliability and validity of the PAIT2.

The aims of this study are presented in two parts. The first part is to assess if the developments of PAIT2 provide a reliable tool by reassessing university-aged healthy student-athletes at time points replicating the acute phase of SRC management. The authors aimed to assess the validity of PAIT2 by comparing a healthy and concussed group for significant differences and to provide a reliable change index that could help clinicians to classify patients as impaired or recovered. The second part of this study is to establish the clinical utility of PAIT2 by assessing if the PAIT2 can identify those with perceived academic impairment.

2 | MATERIALS AND METHODS

2.1 | Participants and design

Ethical approval for the study was obtained from the Ethics Review Sub-Committee (approval number). Two groups of participants were recruited via presentations at sport team meetings. Student-athletes at UK, were recruited to the healthy group if they were participating within a performance sport program, were enroled in a higher education course in the 2021/22 academic year and did not have an SRC. After informed consent was gained, healthy participants were sent an online version of the PAIT2 questionnaire at days 0, 2, 4, 8, 14 and 19. These time points were used to reflect when concussed athletes were followed up acutely from SRC and to enable tracking of the recovery trajectory. Concussed participants were recruited from an ongoing study investigating the effects of early exercise on the recovery of symptom burden, neurocognition and vestibular-oculomotor function and academic ability. Concussed participants had the same inclusion criteria with the addition of participating in the Rugby Union sport program and competing in either the British Universities Competition or National League competition. Participants in the SRC group were recruited and screened during their preseason (July–September 2021). Concussed participants completed the PAIT2 at the same time points (1.68 ± 0.61, 4.61 ± 1.17, 8.75 ± 1.48, 14.11 ± 0.62 and 27.58 ± 9.28 days post-SRC). Of the concussed group, 18 participants were able to Return-to-Play (RTP) as expected (21.16 ± 1.78 days), 6 within a month (28.28 ± 3.10 days) and 4 had a protracted recovery (37.40 ± 5.56 days). The percentage of contact (seminars, workshops, lectures, laboratory and sessions) and non-contact academic time (self-study, revision, writing, reading etc) specifically missed due to their SRC was also recorded. Their symptom threshold exercise tolerance was also assessed, and participants exercised daily at 80% of this. Concussed participants followed the Rugby Football Union (RFU) community pathway (Rugby, 2019) resulting in no less than 19 days before RTP. Student-athletes followed the RTL guidelines (McCrory et al., 2017), and progression of RTL was managed by their referring clinician.

The PAIT2 is a questionnaire that asks participants to rate their perceived ability on 23 different academic tasks (Appendix A). The PAIT2 was developed from previous work by Glendon et al. (2021a, 2021b), and a full description of this is provided in the Supporting Information S1. To prevent central tendency bias, a 7-point scale was used and participants rated themselves according to a statement rather than a value (Jeb et al., 2021). The worded responses correspond to a number 0–6, where 0 is no impairment and 6 is maximally impaired. For example, the participant is asked; "during academic activities (lectures, seminars, workshops, labs and self-study) how often can you stay on task?". The participant is asked to respond with either always, most of the time, frequently, sometimes, not often, hardly ever or never, which is rated 0–6, respectively. The responses are summed to provide an academic ability score ranging from 0 to 138. Healthy participants were sent the PAIT2 to complete online on the day they needed to complete the questionnaire and reminded later that day to complete it. If healthy participants did not complete the questionnaire on a specific day, their data were excluded from the analysis. Concussed participants completed the questionnaire online themselves without input from the researcher on a laptop during their reassessment post-SRC at day 2, 4, 8, 14 and prior to RTP.

2.2 | Statistical analysis

Individual change on PAIT2 was calculated at each reassessment time point (PAIT2 score change = PAIT2 score at reassessment time point–baseline) and presented as means and standard deviation (SD). Individual score change was used in all analysis to reflect recommendations in the literature for other assessment methods in this field (Czerniak et al., 2021). A score increase indicated worsening academic impairment, and a score decrease indicated an improvement in perceived academic ability. Due to the distribution and skewness within the data, non-parametric tests were performed. To establish if PAIT2 is a reliable and repeatable measure of academic impairment, a Friedman's test was used to indicate if change from baseline to each reassessment time point was significant and a Cronbach's Alpha test at each reassessment time point was used to test the internal validity of the PAIT2 questionnaire. To explore further the test-retest reliability, Intraclass Correlation Coefficients (ICCs) were used rather than other interclass correlations, such as Spearman's or Pearson's, due to retesting on two or more occasions (Koo et al., 2016). ICCs were calculated using a mean rating, absolute agreement and two-way mixed effects model to take into consideration individual score change and multiple measurements producing a composite score (Koo et al., 2016).

For a clinical application of PAIT2, a Reliable Change Index (RCI) was calculated using two-tailed 70, 80 and 90% Confidence Intervals

(CIs) (z = 1.04, 1.28 and 1.64). The RCI indicates the threshold for reliable change to occur in individual PAIT2 scores compared to baseline at a 70, 80 or 90% CI (Speer et al., 1995). The SD from each reassessment time point and ICC was used to calculate the standard error of measurement (SEM) at each assessment time point (SEM2 = day 2, SEM4 = day 4, SEM8 = day 8, SEM14 = day 14 and SEM19 = day 19). The SEM at each time point was used to calculate the Standard Error of Difference (SE_{diff}) and eventually the RCI.

1. $SEM = SD\sqrt{1 - ICC}$
2. $SE_{diff} = \sqrt{SEM2^2 + SEM4^2 + SEM8^2 + SEM14^2 + SEM19^2}$
3. SE_{diff} multiplied by ± 1.04 (70% CI), ± 1.28 (80% CI), and ± 1.64 (90% CI)

Clinical significance between the healthy and concussed group was established with the Mann–Whitney U test (significance level <0.05, Bonferroni corrected). Following this, the clinical utility of PAIT2 was established by calculating sensitivity, specificity, positive predictive values (PPVs), negative predictive values (NPVs) and positive and negative likelihood ratios (LR+, LR-). The sensitivity value indicates how well PAIT2 will correctly identify participants without impairment and specificity indicates how well it can identify those with impairment (Swift et al., 2020). The PPV and NPV indicate the probabilities of participants having or not having PAIT2 impairment within this cohort (Akobeng, 2007), and the LR+ and LR-are presented to allow for comparison to other populations (Boyer et al., 2003). These have been calculated using the following equation:

$$\text{Sensitivity} = \text{TP}/(\text{TP} + \text{FN})$$

$$\text{Specificity} = \text{TN}/(\text{TN} + \text{FP});\ \text{Positive Predictive Values} = \text{TP}/(\text{TP} + \text{FP})$$

$$\text{Negative Predictive Values} = \text{TN}/(\text{TN} + \text{FN})$$

$$\text{Positive Likelihood Ratio} = \frac{\text{TP}/(\text{TP} + \text{FN})}{\text{FP}/(\text{TN} + \text{FP})}$$

$$\text{Nagative Likelihood Ratio} = \frac{\text{FN}/(\text{TP} + \text{FN})}{\text{TN}/(\text{TN} + \text{FP})}$$

where True Positive (TP), False Positive (FP), False Negative (FN) and True Negative (TN).

Participants were defined as impaired on PAIT2 if they had an equal or greater score increase on PAIT2 according to the 80% CI RCI based on recommendations in previous medical research (Speer et al., 1995). Sensitivity, specificity, PPV, NPV, LR+ and LR-were initially calculated for the whole cohort at day 2, 4, 8, 14 and 19/RTP. To take into consideration, not all participants post-SRC experiencing a neurocognitive deficit, the calculations were repeated, but this time only including those who had a 80% CI RCI decrease in a composite score on Immediate Post Concussion Test (ImPACT) (verbal memory = 8.75, visual memory = 13.55, reaction time = 0.06 milliseconds, motor processing speed = 4.98 and PCSS = 9.18 points (Iverson et al., 2003)). The reliability of ImPACT to identify neurocognitive deficits following SRC has been questioned (sensitivity 81.9%–58.7% and specificity 89.4%–53.2%) (Czerniak et al., 2021; Schatz et al., 2006), but outside of more advanced investigations, such as Diffusion Tensor Imaging and functional MRI, no other clinical tests offer better reliability (Czerniak et al., 2021). To explore this further, the same calculations were conducted for just the concussed group to indicate if PAIT2 could identify those with or without either a neurocognitive decline on ImPACT or reported academic time loss. In the concussed group only, the same calculations were done to analyse if combining PAIT2 with presence of academic time loss improved the reliability of identifying those with impairment on ImPACT.

3 | RESULTS

A total of 69 participants were recruited to the study (n = 41 healthy group (n = 16 excluded for not completing the questionnaire at all-time points, resulting in n = 25 included) and n = 28 concussed group) (Appendix B). The average time to return-to-play for the concussed was 27.58 ± 9.28 days (median; 23, IQR; 20.75–31.75 and range; 19–54 days). Self-report of time to return to a full academic timetable was 13.68 ± 12.99 days (median; 11, IQR; 4.00–15.25 and range; 2–54 days).

3.1 | Part one—Establishing reliability and validity

The PAIT2 tool had good internal reliability, and there was no learning effect with repeated completion (χ^2 (25) = 2.128, p = 0.712) (Table 1 and Figure 1). The PAIT2 had a good level of reliability (0.880 [95% CI: 0.785–0.941]). Based on a 70, 80 or 90% CI, a RCI of 3.763, 4.631 and 5.933 could be used to indicate a significant change in score. Concussed participants reported a score increase greater than the 80% CI RCI at day 2 and had significantly worse perceived academic ability at 2 days post-SRC compared to the healthy group (6.65 ± 12.60 vs. −1.48 ± 3.54, U = 201.000, z = −2.660 and p = 0.040) (Table 2).

3.2 | Part two—Clinical utility of PAIT2

Analysis indicated PAIT2 would be able to recognize 96% of concussed student-athletes with academic impairment at day 2, 92% at day 4, 85.71% at day 8% and 92% at day 14 and 19. Conversely, PAIT2 was only able to correctly identify 55.56% without academic impairment at day 2, 36.84% at day 4, 16.67% at day 8% and 12.50% at day 14. This demonstrates PAIT2 is highly specific for detecting self-perceived academic impairment but is not reliable at ruling out academic impairment if no change in PAIT2 score is seen (Table 3). PPV values indicate an increase of PAIT2 score at day 2 and 4 was highly probable of the participant being in the concussed group. The LR+ scores at day 2

TABLE 1 Score change (mean and standard deviations) compared to baseline, internal reliability and standard error of measurement.

	Mean score change (SD)	Cronbach's alpha	Standard error of measurement
Baseline	n/a	0.826	n/a
Day 2	−1.48 ± 3.54	0.771	1.494
Day 4	−2.04 ± 5.37	0.790	1.497
Day 8	−1.48 ± 5.11	0.793	1.483
Day 14	−1.40 ± 4.53	0.808	1.873
Day 19	−2.12 ± 4.69	0.791	1.597

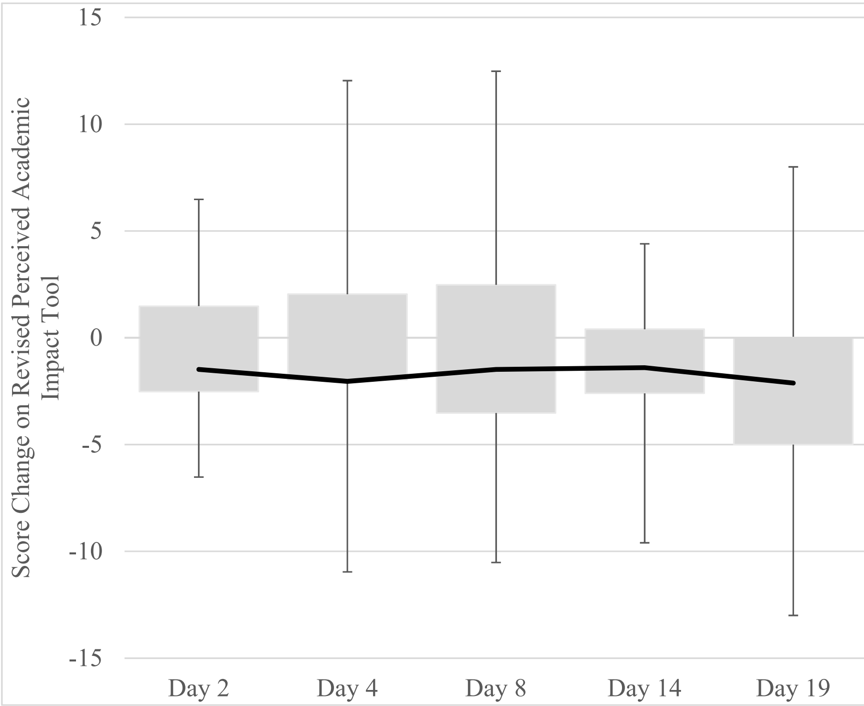

FIGURE 1 Boxplot of change from baseline at each reassessment time point in healthy individuals.

TABLE 2 Score change (mean and standard deviations) from baseline score of PAIT2 for healthy and concussed participants.

	Healthy participants		Concussed participants		
	Cohort score	Individual change	Cohort score	Individual change	*p*
Baseline	44.92 ± 12.30	n/a	45.86 ± 12.51	n/a	
Day 2	43.44 ± 10.91	−1.48 ± 3.54	52.50 ± 15.34	6.65 ± 12.60	0.040
Day 4	42.88 ± 10.81	−2.04 ± 5.37	48.64 ± 16.15	2.79 ± 11.63	0.092
Day 8	43.44 ± 10.78	−1.48 ± 5.11	40.39 ± 16.15	−5.46 ± 9.81	0.148
Day 14	43.52 ± 11.43	−1.40 ± 4.53	41.79 ± 11.51	−4.07 ± 8.30	0.211
Day 19/RTP	42.80 ± 11.03	−2.12 ± 4.69	41.71 ± 13.20	−4.25 ± 7.57	0.214

and 4 suggest a high likelihood of impairment if there was an 80% CI RCI increase in PAIT2. The sensitivity of PAIT2 was marginally improved at day 2, and NPV at all-time points when only those with impairment on ImPACT or academic time loss were considered. Therefore, if student-athletes had no impairment on ImPACT or reported no academic time loss and there was no change in PAIT2 score, then no academic impairment was likely to be present. However, relying on ImPACT impairment or academic time loss to assume academic impairment may not indicate the extent of self-perceived academic impairment.

TABLE 3 Specificity, sensitivity, Positive Predictive Value (PPV), Negative Predictive Value (NPV), Positive Likelihood Ratios (LR+) and Negative Likelihood Ratios (LR-) for impairment on the Perceived Academic Impact Tool (PAIT2) each reassessment time point for all participants or those with a 80% CI RCI decline in performance on the Immediate Post Concussion Assessment Test (ImPACT) composite, or the concussed participants only, grouped by impaired or not using a 80% CI RCI decline in performance ImPACT (*n* = number of participants).

	Healthy participants (*n*)		Concussed participants (*n*)							
	<RCI	>RCI	<RCI	>RCI	Specificity	Sensitivity	PPV	NPV	LR+	LR-
All participants										
Day 2	24	1	14	14	96.000	50.000	93.333	63.158	12.500	0.521
Day 4	22	3	17	11	92.000	39.286	78.571	56.410	4.911	0.660
Day 8	22	3	22	3	85.714	12.500	50.000	50.000	0.875	1.021
Day 14	21	4	24	4	92.000	14.286	50.000	46.667	1.786	0.932
Day 19/RTP	22	3	24	4	92.000	14.286	57.143	47.826	1.786	0.932
Concussed group - participants with ImPACT RCI decline										
Day 2	24	1	6	8	96.000	57.143	88.889	80.000	4.480	0.051
Day 4	23	2	9	6	92.000	40.000	75.000	71.875	4.667	0.000
Day 8	22	3	16	1	88.000	5.882	25.000	57.895	1.760	0.240
Day 14	23	2	11	2	92.000	15.385	50.000	67.647	1.515	0.204
Day 19/RTP	23	2	9	0	92.000	n/a	0.000	71.875	1.171	0.373
Concussed group - participants with academic time loss										
Day 2	24	1	10	8	96.000	55.556	88.889	70.588	13.889	0.463
Day 4	22	3	12	7	92.000	36.842	70.000	64.706	4.605	0.687
Day 8	22	3	15	3	88.000	16.667	50.000	59.459	1.389	0.947
Day 14	21	4	7	1	92.000	12.500	20.000	75.000	1.563	0.951
Day 19/RTP	22	3	0	0	92.000	n/a	0.000	100.000	n/a	n/a
Concussed participants only, grouped by impaired or not using a 80% CI RCI decline in performance ImPACT										
Day 2	1	12	10	5	66.667	92.308	90.909	70.588	2.769	0.115
Day 4	11	3	11	3	21.429	78.571	50.000	50.000	1.000	1.000
Day 8	6	4	8	10	40.000	44.444	57.143	28.571	0.741	1.389
Day 14	7	8	4	9	53.333	30.769	36.364	47.059	0.659	1.298
RTP	5	14	1	8	73.684	11.111	16.667	63.636	0.422	1.206

In just the concussed group, combining the presence of academic time loss and an RCI change in PAIT2 scores was not more sensitive to detecting those with academic impairment, though if academic impairment was found, it was highly probable that the participant was impaired on ImPACT. The combination demonstrated higher sensitivity scores, indicating it was superior at ruling out impairment at day 2, 4, and 8 compared to the other models (Table 3).

4 | DISCUSSION

This repeated-measures study investigated the reliability, validity and clinical utility of a novel tool to quantify self-perceived academic impairment and found that the PAIT2 tool had good reliability and internal validity. At day 2, concussed student-athletes had significant academic impairment compared to healthy student-athletes, and this decline was greater than the 80% CI RCI. PAIT2 scores were not significantly different or greater than the 80% CI RCI change at day 4, indicating probable recovery of perceived academic ability by day 4. The PAIT2 assessment tool was specific to detecting academic impairment within 19 days of an SRC, and an increase in score greater than the 80% CI RCI (4.631) is highly probable of self-perceived academic impairment. PAIT2 was able to detect 96.00%, 92.00%, 85.71% and 92.00% of concussed student-athletes with academic impairment at day 2, 4, 8 and 14 days post-SRC with a reliability of 88.89%, 75.00%, 25.00% and 50.00% demonstrating this was a true positive (Table 3). No change in PAIT2 score provides a good assurance of no self-perceived academic impairment if no impairment is also seen on ImPACT and student-athletes can attend all academic activities. Clinically, ImPACT and academic time loss were not superior to identifying academic impairment compared to PAIT2, but the use of ImPACT, academic time loss and PAIT2 in a battery was superior for ruling out academic impairment than just PAIT2. Therefore, the addition of PAIT2 into an assessment battery would provide clinicians with a greater insight into how SRC affects perceived academic ability of university aged student-athletes, what academic accommodations may be needed and when to progress them along the RTL protocols.

Findings in this study demonstrate this novel assessment method, the PAIT2, is a reliable and valid measurement of academic impairment following an SRC. Other studies report concussed student-athletes have poorer grades (Alexander et al., 2015; Lowry et al., 2019; McLeod et al., 2017), an increased need for academic adjustments (Wan et al., 2021; Wasserman et al., 2016) and a delayed RTL (Wasserman et al., 2016). The findings of these studies demonstrate academic adjustments may be required by some post SRC, but they do not indicate what severity of academic impairment is experienced, provide a method to assess how academic ability is recovering or indicate what academic adjustments are required. The PAIT2 provides an assessment method that may help to identify and establish the severity of academic impairment. Clinical use of PAIT2 could be employed to assess when student-athletes may progress the level of academic challenge and ensure student-athletes progress along RTL protocols at the correct pace. Further studies are needed to establish if progressing the demands of academic activities prior to PAIT2 scores returning to within an RCI change affects academic impairment recovery or time to RTL. If an association were to be found, this would help clinicians to improve the quality of care offered by informing when to progress along the RTL protocols.

Aforementioned studies have recruited children or adolescents, and this has been used to form RTL protocols for collegiate student-athletes. Previous studies have also only assessed at a single time point post-SRC and mainly recruited participants from concussion clinics, whereas student-athletes in this study were recruited sequentially. This is the first study to assess the severity of academic impairment in collegiate-aged student-athletes and monitor individual change from baseline across multiple reassessment time points. Recent consensus guidelines suggest it may take up to 5 days to RTL (Patricios et al., 2023), however, results from this study suggest perceived academic ability in collegiate student-athletes recovers by day 4 on PAIT2 but return to full academic timetable took much longer (13.68 $\pm$ 12.99 days, median; 11, IQR; 4.00–15.25 and range; 2–54 days). RTL in the current study was evaluated in two ways, firstly, perceived academic ability returning to within 80% RCI of baseline score and secondly, when student-athletes were able to return to a full academic timetable. Previous studies have recorded when student-athletes returned to the classroom regardless of how well they could complete academic activities or how much of the timetable they attended (Babcock et al., 2013; Russell et al., 2016). Furthermore, UK university student-athletes have different amounts of academic contact time scheduled depending on their course and what period of the semester they are in. Therefore, defining RTL solely as when student-athletes returned to the classroom may not indicate when academic recovery has occurred. The percentage of academic timetable completed and perceived academic ability on the PAIT2 may more accurately indicate when academic recovery has occurred.

Previous studies have also recruited participants from concussion clinics where those with more severe concussions are likely to report due to symptoms not resolving. This, along with the current study defining RTL as when student-athletes had returned to full academic timetable, may explain why the student-athletes in this study generally reported a much quicker recovery on PAIT2, whilst the more severely concussed student-athletes in this study took a similar time to a full academic timetable as found in studies recruiting from concussion clinics (Ransom et al., 2015; Russell et al., 2019). Furthermore, no studies have been published that have recruited UK-based student-athletes. Most research in this field has been conducted in the USA where collegiate-aged student-athletes receive academic accommodations far beyond what is offered in UK student-athletes in higher education (Otto et al., 2019). Due to the extent of academic adjustments for USA-based student-athletes, pre-existing accommodations may be partially adequate or require just minor adjustments to ensure academic activities are not detrimental to the student-athletes' recovery. This study has demonstrated that academic impairment is commonly seen following a SRC, and therefore, UK higher education institutions should be aware of the impact SRC can have in the short-term and acknowledge that academic adjustments are required.

Previous studies have assessed academic impairment following an SRC by monitoring change in grades with some studies showing long-term effects (Alexander et al., 2015; Ilie et al., 2020) and others not (Gabbe et al., 2014; McKinlay, 2002; Rieger et al., 2019; Russell et al., 2016). PAIT2 offers the ability to explore the severity and dimensions of academic impairment over time, whereas academic assessments vary considerably and occur at unknown and disparate time intervals. Grades were unaffected at national examinations at age 15–16 in those who had sustained a concussion aged 0–10 (McKinlay, 2002) or at key stage 1 (age 5–7 years) (Gabbe et al., 2014) or the following year (Russell et al., 2016). In 13–17 year olds still experiencing post-concussion symptoms, there was no significant decline in cognitive performance, academic measures of vocabulary, word recognition or reading comprehension compared to healthy controls (Rieger et al., 2019). It may be that changes in academic grades are not sensitive enough to detect changes in academic performance, and therefore, other measures are warranted. Further studies could consider utilizing PAIT2 to investigate if it is able to identify impaired academic ability in long-term cases or in those with post-concussion syndrome.

4.1 | Limitations

RTL was measured by percentage missed, and RTL was defined as when there was no longer any academic time loss rather than when student-athletes were first able to resume classes. Other studies may have used different definitions and measures of when RTL occurred. The current study recruited 25 participants to the healthy group and 28 concussed participants, but both groups contained more males that females. Participants were recruited from convenience sampling with more males consenting to the healthy group. A greater number of males participated in rugby union at the university, and hence, more males suffered a concussion and were included in the concussed group. Future studies should attempt to recruit an even number of males and females. The literature suggests females report greater symptom burdens than males (McCrory et al., 2017), and therefore, the results from this study may not be applicable to females. Group sizes did not allow for analyses of the effect of confounding variables, such as sex, learning disability and mental health diagnoses. Therefore, larger scale studies recruiting greater numbers are warranted that allow analysis of how confounding factors may affect perceived academic ability. Whilst this was a relatively small cohort compared to other studies referred to in this paper, the number needed to treat calculations based on the ICC values (Bujang et al., 2017) indicated that only 12 were required to be recruited to the healthy group. Participants were only recruited from one centre, and therefore, application of these results to other institutions or environments may be limited. Furthermore, application of these results to children and adolescent aged student-athletes should be done with caution until studies have established if PAIT2 has good reliability, validity and clinical utility in younger age groups. The healthy group were recruited across the academic year when academic pressure may have fluctuated. Clinicians should be mindful that academic stress may influence perceived academic ability. Only student-athletes were recruited to this study, and non-athlete students may not report the same academic ability and application of this assessment method to a non-sporting cohort may reveal different RCI, sensitivity, specificity, PPV, NPV or likelihood ratios.

5 | CONCLUSIONS

The PAIT2 tool has been shown to demonstrate good reliability and internal validity. PAIT2 specificity values indicate that it is able to identify a high percentage of participants with academic impairment following SRC, and the PPV indicates an increase in score greater than the RCI of 4.631 is highly likely to reflect a true positive. When combined with other tests, ImPACT and academic time loss, the reliability to rule out academic impairment is improved. This is the first study to use a questionnaire-based tool to identify and measure the severity of academic impairment, and therefore, further studies are required in different academic establishments, other age groups and non-sporting populations prior to the PAIT2 being used to inform clinical decisions. Further, larger scale studies are needed to assess if confounding variables, such as sex, learning disabilities and mental health diagnoses, affect change in PAIT2 scores.

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CONFLICT OF INTEREST STATEMENT

The authors report no conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

APPENDIX A

See Table A1.

TABLE A1 Revised perceived academic impact tool (PAIT2).

During academic activities (lectures, seminars, workshops, labs and self-study) how often can you;							
	Always	Most of the time	Frequently	Sometimes	Not often	Hardly ever	Never
Stay on task							
Pay attention and take notes at the same time							
Keep up with what's going on during lectures, seminars and labs							
Understand material the first time and don't need it repeating							
Understand material on a screen							
Work with bright lights on							
During academic activities (lectures, seminars, workshops, labs and self-study) what percentage do these statements describe you?							
	0%	15%	30%	50%	65%	80%	100%
I day dream in class							
I remember what I learnt last week							
I remember what I learnt at uni when I get home							
I finish my work at the same pace as my peers							
I don't get tired doing uni work							
I don't get a headache doing uni work							
During academic activities (lectures, seminars, workshops, labs and self-study) how much are these statements true reflection of you?							
	Always	Usually	Often	Occasionally	Rarely	Usually not	Never
I work harder than my peers to keep up with the same amount of work							
I fall asleep in class							
I understand material as quickly as my peers							
I finish tasks I have started							
I keep up to date with my uni work							
During academic activities (lectures, seminars, workshops, labs and self-study) how well can you do these tasks?							
	Impossible for me	Very difficult	Difficult	Sometimes ok	Mostly ok	Easy	Very easy
Work on challenging tasks for more than 30 min							
Work with loud noises							
Problem solve							
Understand material present in lectures							
Clearly communicate my thoughts							
I can use a computer, laptop, tablet or mobile phone with no issues							

See Table A2.

TABLE A2 Revised perceived academic impact tool (PAIT2) scoring sheet.

During academic activities (lectures, seminars, workshops, labs and self-study) how often can you;							
	Always	**Most of the time**	**Frequently**	**Sometimes**	**Not often**	**Hardly ever**	**Never**
Stay on task	0	1	2	3	4	5	6
Pay attention and take notes at the same time	0	1	2	3	4	5	6
Keep up with what's going on during lectures, seminars and labs	0	1	2	3	4	5	6
Understand material the first time and don't need it repeating	0	1	2	3	4	5	6
Understand material on a screen	0	1	2	3	4	5	6
Work with bright lights on	0	1	2	3	4	5	6
During academic activities (lectures, seminars, workshops, labs and self-study) what percentage do these statements describe you?							
	0%	**15%**	**30%**	**50%**	**65%**	**80%**	**100%**
I daydream in class	0	1	2	3	4	5	6
I remember what I learnt last week	6	5	4	3	2	1	0
I remember what I learnt at uni when I get home	6	5	4	3	2	1	0
I finish my work at the same pace as my peers	6	5	4	3	2	1	0
I don't get tired doing uni work	6	5	4	3	2	1	0
I don't get a headache doing uni work	6	5	4	3	2	1	0
During academic activities (lectures, seminars, workshops, labs and self-study) how much are these statements true reflection of you?							
	Always	**Usually**	**Often**	**Occasionally**	**Rarely**	**Usually not**	**Never**
I work harder than my peers to keep up with the same amount of work	6	5	4	3	2	1	0
I fall asleep in class	6	5	4	3	2	1	0
I understand material as quickly as my peers	0	1	2	3	4	5	6
I finish tasks I have started	0	1	2	3	4	5	6
I keep up to date with my uni work	0	1	2	3	4	5	6
During academic activities (lectures, seminars, workshops, labs and self-study) how well can you do these tasks?							
	Impossible for me	**Very difficult**	**Difficult**	**Sometimes ok**	**Mostly ok**	**Easy**	**Very easy**
Work on challenging tasks for more than 30 min	6	5	4	3	2	1	0
Work with loud noises	6	5	4	3	2	1	0
Problem solve	6	5	4	3	2	1	0
Understand material presented in lectures	6	5	4	3	2	1	0
Clearly communicate my thoughts	6	5	4	3	2	1	0
I can use a computer, laptop, tablet or mobile phone with no issues	6	5	4	3	2	1	0

APPENDIX B

See Table B1.

TABLE B1 Demographics of healthy and concussed groups.

	Healthy participants	Concussed participants
n	25	28
Sex (male, *n* (%))	19 (76.00)	17 (60.17)
Age (median, IQR)	20.28	20.90
Course level, *n* (%)		
Foundation	1 (4.00)	3 (10.71)
Undergrad	23 (92.00)	20 (71.43)
MSc	1 (4.00)	4 (14.90)
PhD	0 (0.00)	1 (3.57)
University year, *n* (%)		
1	13 (52.00)	13 (46.43)
2	5 (20.00)	10 (35.71)
3	1 (4.00)	2 (7.14)
4	4 (16.00)	3 (10.71)
5	2 (8.00)	0 (0.00)
ADHD, *n* (%)	1 (4.00)	1 (3.57)
Depression, *n* (%)	2 (8.00)	0 (0.00)
Dyslexia, *n* (%)	1 (4.00)	4 (14.29)
Sport		
Hockey, *n* (%)	20 (80.00)	0 (0.00)
Tennis, *n* (%)	3 (12.00)	0 (0.00)
Rugby, *n* (%)	2 (8.00)	28 (100.00)
Time to follow-up (mean, standard deviation)		
Day 2	2.00 ± 0.00	1.68 ± 0.61
Day 4	4.00 ± 0.00	4.61 ± 1.10
Day 8	8.00 ± 0.00	8.75 ± 1.48
Day 14	14.00 ± 0.00	14.11 ± 0.62
Day 19/RTP	19.00 ± 0.00	27.58 ± 73.38