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Physical activity and recovery following concussion in collegiate athletes: a LIMBIC MATARS Consortium Investigation

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ABSTRACT

Objective: To investigate whether routine daily activities (RDA), non-prescribed exercise (Non-ERx), or prescribed exercise (ERx) were associated with recovery from sport-related concussion (SRC) in collegiate athletes.

Materials and Methods: Data for this cross-sectional, retrospective chart review of collegiate athletes diagnosed with SRC (*n* = 285[39.6% female], age = 19.5 ± 1.4 years) were collected during the 2015–16 to 2019–20 athletic seasons. The independent variable was group (RDA, Non-ERx, ERx). Dependent variables included days from date of diagnosis to symptom resolution (Dx-SR) and SR to return to sport (SR-RTS).

Results: Those in the Non-ERx group took nearly 1.3 times longer to achieve SR (IRR = 1.28, 95% CI: 1.11, 1.46) and, 1.8 times longer for RTS (IRR = 1.82, 95% CI: 1.11, 2.71) when compared to those in the RDA group. No other comparisons were significant.

Conclusion: Collegiate athletes in the Non-ERx group took approximately 1 week longer to achieve SR as compared to the RDA and ERx groups. Our findings suggest that if exercise is recommended following SRC, it must be clearly and specifically prescribed. If exercise parameters cannot be prescribed, or monitored, RDA appear to be similarly beneficial during recovery for collegiate athletes with concussion.

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Mild traumatic brain injury (mTBI); exercise; exercise prescription; rehabilitation; head injury

Introduction

Consensus on returning athletes to primarily aerobic physicial activity during the acute phase following a sport-related concussion (SRC) has evolved over the past decade (1). Until 2017, guidelines for concussion management included complete rest (i.e., restraint from physical activity) until patients achieved symptom resolution (SR) (2–4). Recent evidence, however, has led to evolved guidelines that suggest a brief physical and cognitive rest period after injury (24–48 hours) followed by a gradual increase in symptom-limited physical activity (5). Specifically, there is growing evidence that favors subsymptom threshold exercise that does not exacerbate patient concussion symptoms (6–9) following the acute phase (~48 hours) of recovery. Rationale for exercise as medicine is theorized to be primarily physiological. Exercise intolerance following concussion is purported to be a consequence of dysregulation of the autonomic nervous system (10), reduced cardiovascular function (11), and impaired regulation of cerebral blood flow (12); all of which are maladaptive physiologic functions that improve with aerobic physical activity (13). Furthermore, exercise has been demonstrated to be beneficial for symptoms of anxiety and depression which commonly occur following concussion (14–16). Therefore, introducing monitored subsymptom threshold exercise early in concussion recovery may facilitate a reduced number of days to SR as compared to rest alone by reducing symptom severity and duration, and improving quality of life (6,17).

Higher frequency and volume of self-selected physical activity, that is safe from exposure to sport-related contact/collision, is associated with an earlier return to sport (RTS) following concussion (18,19). Moreover, monitored and/or prescribed exercise is increasingly recognized as being safe and effective for managing symptoms and promoting recovery from concussion, particularly in early stages following injury (7,20) and mitigating the risk of persisting symptoms after concussion, especially in adolsecents (6,21–24). For example, in a randomized control trial, adolescent athletes who were prescribed and adhered to the Buffalo Concussion Treadmill

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Test exercise prescription achieved a lower symptom burden and recovered, on median, 6 days earlier than participants who were prescribed a stretching protocol (23). However, evidence-based recommendations for the optimal frequency, intensity, type, and time (FITT) of the exercise prescription following concussion have yet to be established. Complicating the establishment of a FITT prescription for concussion is the heterogenous exercise prescriptions across studies. Further, evidence for exercise prescription during concussion recovery among collegiate athletes is limited (18,25) especially in an ecologically valid setting (i.e., clinician directed rather than researcher directed interventions). Therefore, there is a pressing need to inform exercise prescription after concussion to improve clinical care standards and patient outcomes among collegiate athletes.

The objective of our study was to investigate the influence of exercise on the number of days from injury diagnosis to clinical recovery benchmarks for collegiate athletes with concussions. Specifically, we sought to understand how routine daily activity (RDA), non-prescribed exercise (Non-ERx), or prescribed exercise (ERx) following concussion were associated with clinical recovery milestones. We hypothesized that the shortest timelines would be associated with ERx, followed by Non-ERx and RDA for days from diagnosis to SR and to return-to-sport (RTS).

Materials and methods

Research Design

Our cross-sectional study included data from retrospective chart reviews of collegiate athletes diagnosed with SRCs from the 2015–2016 through 2019–2020 sport seasons. Data from consensus-based common data elements related to our independent and dependent variables were extracted, recorded, and aggregated from LIMBIC Military and Tactical Athlete Research Study (MATARS) consortium member sites ($n = 11$) as previously described (cite methods paper under review). We secured Institutional Review Board approval at the University of Virginia and at each member site. In addition to IRB approval, data use and confidentiality disclosure agreements between the LIMBIC MATARS host site PI (JER) and the consortium institution administrators were established prior to the collection and submission of deidentified data.

Participants

There were 1,311 documented SRCs among collegiate athletes from participating institutions during the study period. Of those, 25% ($n = 285$ [37.5% female]; Table 1) met inclusion criteria for the current study (see Figure 1 for CONSORT flow diagram). Inclusion criteria included cases where all independent and dependent variable information were available and demographic variables we felt were important to compare across groups (26). Variability in group membership (RDA, Non-ERx, ERx) existed across data collection sites; however, questions regarding group membership were resolved via direct communication between the lead PI (JER) and the lead researchers at each data collection site.

Data collection procedures

Suspected SRCs were assessed, diagnosed, documented, and treated by LIMBIC MATARS site-specific licensed medical professionals (e.g., certified athletic trainers or physicians) in accordance with National Collegiate Athletic Association approved policies. Consensus-based common data elements associated with each concussion were entered into medical record platforms by licensed medical professionals at the time of diagnosis at each member site during the five-year study period. SRCs, as well as recovery timepoints, were operationally defined according to the most recent international guidelines at the time of diagnosis and recovery (17,27).

For our study, the independent variable was physical activity type following concussion. Physical activity was categorized into three distinct groups, (i) RDA (e.g., walking to class, no strict physical rest), (ii) Non-ERx (i.e., performing light, moderate, or vigorous exercise without a prescribed FITT prescription), or (iii) ERx (i.e., light, moderate, or vigorous exercise with a specific healthcare provider FITT prescription). Researchers at each consortium member institution coded each concussion case based on the information included in patient medical records and the above criteria. Dependent variables included time (in days) from the date of diagnosis to date until symptom resolution (Dx-SR) and time (in days) from the date of symptom resolution to return to sport (SR-RTS). We chose to use SR and RTS as they are indicative of recovery from concussion. Since there are documented delays in return to sport when concussion reporting and/or diagnosis is delayed (28–30), we assessed the difference in injury date and date of diagnosis and found no statistically significant differences ($p > 0.05$). Therefore, we used the more objective date of diagnosis as our beginning timepoint.

Statistical analysis

To determine the possible influence of the data collection site on primary outcome variables [time (days) from Dx-SR and time (days) from SR-RTS], Kruskal–Wallis tests were used with the data collection site as the independent variable. Time (days) from Dx-SR ([$H_{(7)} = 7.20$, $p = 0.41$] and time (days) from SR-RTS [$H_{(7)} = 9.40$, $p = 0.22$]) were similar between sites; therefore, we collapsed data for analytical procedures.

We calculated descriptive statistics, specifically mean and standard deviations for continuous variables and frequencies with percentages for categorical variables. Chi-squared analyses were then used to determine if distributions of categorical demographic variables (biological sex, race, self-reported history of depression, anxiety, ADD/ADHD, headache, migraine, and previous concussions) and one-way ANOVA for continuous variables (age, height, weight) were equivalent across groups. Due to small cell sizes ($n < 5$), race was collapsed into white and nonwhite, and history of concussion was collapsed into no prior history and presence of prior history. There were no statistically significant differences observed between headache (dichotomous yes or no, $\chi^2_2 = 0.79$, $p = 0.67$), migraine (dichotomous yes or no, $\chi^2_2 = 0.58$, $p = 0.75$), or concussion history (dichotomous yes or no, $\chi^2_2 = 2.8$, $p = 0.26$) between

Table 1. Participant demographic characteristics across levels of the independent variable (RDA: routine daily activity, non-ERx: non-prescribed exercise, and ERx: prescribed exercise).

	Group			
	RDA	Non-ERx	ERx	Total
	n = 213	*n* = 21	*n* = 51	*n* = 285
Height (cm)*	178.8 ± 11.0	185.6 ± 8.4	183.3 ± 11.6	180.1 ± 11.2
Weight (kg)*	77.6 ± 13.7	85.0 ± 6.6	83.2 ± 10.8	79.1 ± 13.0
Age (years)	19.9 ± 1.3	20.0 ± 1.4	20.1 ± 1.7	19.5 ± 1.4
Frequencies n (%)				
Biological Sex *(n = 285)**				
Male	118 (44.6)	19 (90.5)	16 (31.4)	172 (60.4)
Female	95(55.4)	2 (9.5)	35 (68.6)	1113 (39.6)
Race *(n = 257)***				
American Indian or Alaska Native	0 (0.0)	1 (4.8)	0 (0.0)	1 (0.4)
Asian	2 (0.9)	0 (0.0)	0 (0.0)	2 (0.7)
Black or African American	40 (18.8)	5 (23.8)	32 (62.7)	77 (27.0)
Hispanic or Latino	5 (2.3)	0 (0.0)	0 (0.0)	5 (1.8)
Native Hawaiian or Other Pacific Islander	1 (0.5)	5 (23.8)	1 (2.0)	7 (2.5)
White	151 (70.9)	10 (47.6)	16 (31.4)	177 (62.1)
No response	9 (4.2)	0 (0.0)	2 (3.9)	11 (3.9)
More than one race	5 (2.3)	0 (0.0)	0 (0.0)	5 (1.8)
Medical Hx n (%)				
History of Depression *(n = 257)**				
Yes	13 (6.1)	5 (23.8)	10 (19.6)	28 (9.8)
No	200 (93.9)	16 (76.2)	41 (80.4)	257 (90.2%)
History of Anxiety *(n = 213)**				
Yes	19 (9.5)	6 (14.3)	8 (15.7)	30 (10.5)
No	180 (90.5)	15 (85.7)	43 (84.3)	255 (89.5)
History of Headache *(n = 237)*				
Yes	19 (8.9)	3 (14.3)	1 (5.9)	23 (9.7)
No	180 (90.5)	18 (85.7)	16 (94.1)	214 (90.3)
History of Migraine *(n = 255)*				
Yes	21 (9.9)	2 (9.5)	1 (4.8)	24 (9.4)
No	192 (90.1)	19 (90.5)	20 (95.2)	231 (90.6)
History of ADHD *(n = 285)*				
Yes	10 (4.7)	2 (9.5)	10 (19.6)	22 (7.7)
No	203 (95.3%)	19 (90.5%)	41 (80.4%)	263 (92.3)
# Prior Concussion *(n = 278)*				
0	120 (56.3%)	10 (47.6%)	24 (66.7%)	164 (59.0)
1	42 (19.7%)	4 (19.0%)	14 (27.5%)	60 (21.6)
2	25 (11.7%)	0 (0.0%)	2 (3.9%)	27 (9.7)
3	19 (8.9%)	0 (0.0%)	1 (2.0%)	20 (7.2)
4	3 (1.4%)	0 (0.0%)	0 (0.0%)	3 (1.1)
5	4 (1.9%)	0 (0.0%)	0 (0.0%)	4‡ (1.4)

*Statistically significant across the exercise groups (RDA, non-ERx, and ERx) at the 0.05 level.
†Statistically significant across the exercise groups (RDA, non-ERx, and ERx) at the 0.05 level. When collapsed to White vs. Non-white.
‡Acronyms: RDA: routine daily activity, Non-ERx: non-prescribed exercise, and ERx: prescribed exercise.

physical activity groups. However, significant differences were observed across physical activity groups for history of depression (dichotomous yes or no, $\chi^2_2 = 13.5$, $p = 0.001$), anxiety ($\chi^2_2 = 10.8$, $p = 0.005$), ADD/ADHD (dichotomous yes or no, $\chi^2_2 = 13.0$, $p = 0.02$), race ($\chi^2_2 = 32.4$, $p < 0.001$) and biological sex (dichotomous male or female, $\chi^2_2 = 11.6$, $p = 0.003$). We also used one-way ANOVA to determine differences across exercise groups for age, height, and mass, with results provided in Table 1.

Due to the count nature of the outcome variables, two separate multivariable Poisson regresion models (one for time from Dx-SR and one for time from SR-RTS) were created to examine the association between the exercise group and the specific time duration outcome while accounting for covariates. Biological sex (male/female), race (White/Non-white), and history of depression (yes/no) served as covariates as these three variables differed across exercise groups and were statistically associated with both the independent and dependent variables. Due to overdispersion in the Poisson models, negative binomial regression models were used for the final analyses with the same variables. From these models, incidence rate ratios (IRRs) with 95% confidence intervals (CIs) excluding 1.00 were deemed statistically significant. All statistical analyses were performed with SPSS (version 29, IBM Inc, Armonk, NY).

Results

Overall, there were more statistically significant associations during the first timeframe of interest (Dx-SR) than the second (SR-RTS), which could be due to the large amount of variability from SR-RTS. Interestingly, it took males a significantly shorter timeframe to move from Dx-SR than females (IRR = 0.89, 95% CI: 0.82, 0.96), but this association did not hold true for SR-RTS (IRR = 1.37, 95% CI: 1.03, 1.82). In other words, males moved quicker from Dx-SR, but slower than females from SR-RTS. It took white athletes significantly longer to

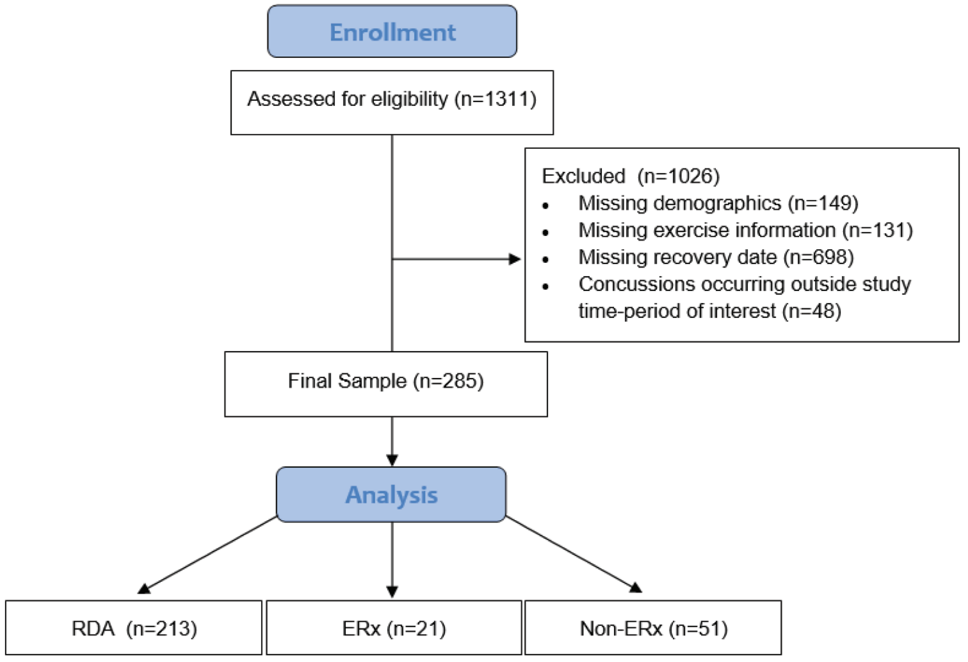

Figure 1. CONSORT flow diagram for data cleaning.

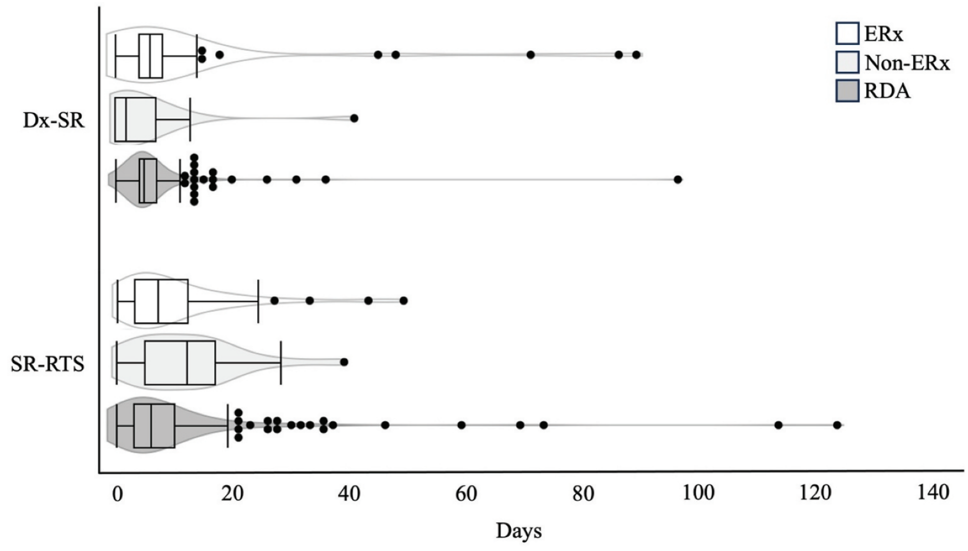

Figure 2. Violin plots of the dependent variables (dx-SR and SR-RTS) across exercise groups (ERx, non-ERx, and RDA).
Acronyms: RDA: routine daily activity, Non-ERx: non-prescribed exercise, and ERx: prescribed exercise, Dx-SR: days from diagnosis to symptom resolution, SR-RTS: days from diagnosis to return to sport.

reach SR than nonwhite athletes (IRR = 1.12, 95% CI: 1.03, 1.23). Those without a diagnosed history of depression reached SR faster than those with a diagnosed history (IRR = 0.73, 95% CI: 0.65, 0.82).

For the primary research question, descriptive statistics can be found in Table 2. Those in the Non-ERx group took significantly longer, nearly 1.3 times longer, to achieve SR (IRR = 1.28, 95% CI: 1.11, 1.46) and, 1.8 times longer for RTS (IRR =

Table 2. Descriptive statistics (median, minimum, and maximum) for days from diagnosis to symptom resolution and symptom resolution to return to sport across exercise group type.

	Time (days) from Dx-SR		Time (days) from SR-RTS	
Variable	Median	(Minimum, Maximum)	Median	(Minimum, Maximum)
RDA	6	(0, 123)	5	(0, 96)
Non-ERx	12	(0, 39)	2	(0, 41)
ERx	7	(0, 49)	6	(0, 89)

Acronyms: RDA: routine daily activity, Non-ERx: non-prescribed exercise, and ERx: prescribed exercise, Dx-SR: days from diagnosis to symptom resolution, SR-RTS: days from diagnosis to return to sport.

1.82, 95% CI: 1.11, 2.71) when compared to those in the RDA group (Figure 2). There were no statistically significant differences in days (Dx-SR or SR-RTS) to milestones between those in the ERx group and those in the RDA group and between those in the ERx group and those in the non-ERx group (Table 3).

Discussion

Exercise has been demonstrated to lessen concussion-related symptom severity, days until SR, and mitigate the risk of persisting symptoms of concussion primarily in adolescent athletes (6,21–24) with emerging evidence of its therapeutic benefits in collegiate athletes (31). In our study, we evaluated potential differences in clinical recovery from diagnosis of SRC in collegiate athletes following ERx, non-ERx, or RDAs. As previously mentioned, prior research suggests exercise is associated with symptom reduction (7) and earlier recovery (6–9) from concussion. However, the only statistically significant difference we found was that those in the non-ERx group, who did not receive a FITT prescription, took longer to achieve SR and RTS than those in the RDA and ERx groups. Interestingly, those in the ERx group demonstrated a similar recovery length to those in the non-ERx and those in the RDA groups.

Findings from our retrospective study discourage the use of non-prescribed physical activity in the management of SRC among collegiate athletes. Unique to this study, we observed completion of RDAs as equally beneficial to prescribed exercise, as compared to exercise that is not strictly prescribed, for SR after SRC. Similarly, our findings support the prescription of exercise with specific parameters (FITT) for collegiate athletes with SRC (32). It is possible, partially based on our findings, that unregulated exercise (e.g., exercise not prescribed or monitored by a trained healthcare clinician) could result in delayed SR time following a SRC. Collegiate athletes tend to have increased pressures, actual and perceived, associated with their RTS (i.e., starting position, scholarship, and/or evaluation by professional teams) and may be eager to return to pre-concussion levels of exercise immediately following SRC in order to RTS. Therefore, those in the non-ERx group may have included athletes who exercised to the point of symptom exacerbation with a 'more is better' mentality that resulted in longer recovery milestones due to higher symptom burden (i.e., quantity and severity). A higher symptom burden has been well documented in the concussion literature as the primary modifier of recovery after concussion in athletes at all levels of sport (33). It is also plausible that, in general, collegiate athletes are used to strenuous exercise. Even though they may be told to perform low-intensity exercise, they may exceed subsymptom thresholds while performing exercise that is not closely monitored or prescribed. Additional research on how various exercise parameters influence concussion recovery and RTS in collegiate athletes is necessary, as is stakeholder education on the importance of specific RDAs and exercise prescription following injury diagnosis.

We were not expecting RDA to be similar to ERx based on previous findings supporting ERx over RDA in adolescent populations (9,34). However, few studies have examined the influence of physical activity and exercise in concussion recovery among collegiate athletes (18,25,35). Current practice guidelines (17,36) suggest exercise should be carefully dosed and patients should be monitored while performing physical activity during concussion recovery to ensure symptom exacerbation is avoided. Oversight is important to emphasize, as some providers continue to recommend rest, also known as 'cocooning,' until SR – a practice that may contribute to longer recovery times and, in turn, delayed RTS (6,7,9). It is plausible that collegiate athletes who perform RDA meet the same criteria as FITT prescriptions despite not participating in their sport. For example, the Buffalo Concussion Treadmill Test has been demonstrated to be beneficial for the reduction of total symptom severity and days until SR as compared to rest and stretching (1,23). The Buffalo Concussion Treadmill Test yields an exercise prescription based on Frequency (6 days a week), Intensity (80% of an athlete's heart rate at the termination of the test), Type (treadmill walking or stationary cycling), and Time (20 minutes) (1,23). It is possible that collegiate athletes who elect to walk to class on a college campus as opposed to using public (i.e., bus) or private transportation (e.g., ride-share programs, scooters, etc.) may reach the appropriate exercise frequency, intensity, type, and time

Table 3. Poisson regression results for predicting time (days) from diagnosis to symptom resolution and symptom resolution to return to sport.

	Incidence Risk Ratio (95% Confidence Interval)	
Variable	Time (days) from Dx-SR	Time (days) from SR-RTS
Biological Sex		
Male vs Female	0.89 (0.82–0.96)*	1.37 (1.03–1.82)*
Race		
White vs. Non-white	1.12 (1.03–1.23)*	1.16 (0.84–1.60)
History of Depression		
No vs. Yes	0.73 (0.65–0.82)*	0.79 (0.50–1.25)
Exercise Group		
Non-ERx vs. RDA	1.28 (1.11–1.46)*	1.82 (1.22–2.71)*
ERx vs. RDA	1.09 (0.91–1.21)	0.71 (0.43–1.18)
Non-ERx vs ERx	1.17 (0.99–1.36)	1.10 (0.95–1.30)

*Statistically significant as the 95% Confidence Interval does not contain 1.00 for incidence rate ratios.

via pedestrian activities. Even more intriguing is that collegiate athletes may achieve the desired exercise prescription several times a day by walking to class rather than riding a bus or using other forms of transportation. Future research should examine the prescribed exercise parameters (i.e., subsymptom threshold heart rate, time, and frequency) for RDA in college athletes.

In addition to the potential physiological benefits of physical activity during the recovery from a SRC, the psychological benefits should also be considered. Engaging in exercise is a critical factor to support emotional and social well-being in collegiate athletes after concussion. Symptoms of anxiety and depression are common following a concussion (16) and are known modifiers of clinical recovery and time to RTS (37). The same psychological benefits may be achieved by allowing athletes to participate in RDA as opposed to restricting them. In turn, exercise, participation in team sports, and RDAs have been shown to mitigate symptoms of anxiety and depression in college students (14,15). As such, ERx following concussion may lead to shorter symptom duration and reduce the burden of mental health symptoms following concussion.

The majority of athletes in our study (74.74%, $n = 213$) completed RDA. The remainder of our sample participated in ERx (17.89% [$n = 51$]) and non-ERx (7.37% [$n = 21$]). The observation is likely due to the time period of our data collection which occurred between 2015 and 2020, which was prior to or at the same time that changes to the consensus-guided recommendations for physical activity during concussion recovery were introduced (17). New standards of care proposing a brief (24–48 hours) period of rest followed by a gradual progression of physical activity to facilitate recovery were recommended in 2017 (17). Approximately one-third of the cases included in this study ($n = 81$; RDA = 78, non-ERx = 3; Figure 3) were collected under the preceding clinical guidelines (27) that recommended rest until patients reported SR, which may explain the high proportion of participants completing only RDAs in our study. Following April 2017, when new practice guidelines became readily available, participants in the cases represented in our dataset represented all 3 groups ($n = 204$; RDA = 135, non-ERx = 18, ERx = 51). Notably, all athletes with concussions who completed ERx ($n = 51$) were diagnosed after April 2017 and therefore, occurred when the current guidelines were first published and informed the new (present) standard of care (17). However, the majority of cases after April 2017 included only completion of RDAs ($n = 135$) following injury diagnosis. Therefore, a time gap existed between the release of updated practice recommendations (5) and clinical implementation into patient care. However, it is also possible that the resources required to implement and supervise exercise tolerance testing and subsequent rehabilitation sessions may also be a limiting factor for clinicians.

Although athletes who were in the ERx group recovered similarly to those in the RDA and non-ERx groups, FITT information is lacking for athletes in the ERx group, as well as the timing of exercise initiation following their concussions. Further research should focus on finding the ‘Goldilocks Zone’ (38) for exercise prescription following concussion, including the right FITT prescription to facilitate recovery from concussion without deleterious effects of exacerbating or prolonging symptoms (25). Intensity, based on heart rate, with aerobic activity in adolescents has been demonstrated to facilitate SR and recovery time (6), but little is known about the exercise parameters that support physiological recovery in collegiate athletes. Symptom burden, which is highly subjective, is often the measure used in studies that investigate exercise prescription following concussion. Future research should examine individual characteristics (i.e., athlete and sport type) along with physiological parameters (i.e., heart rate) to guide the understanding and selection of exercise prescription after concussion.

As previously noted, our design was a retrospective chart review of existing medical data. We used consensus-based common data elements when performing our chart review, and each institution managed concussions unique to their respective policies. Though this may be perceived as a limitation, we feel it enhances the ecological validity (i.e., generalizability) of our study. That said, a minority of collegiate athletes with concussion in our study were prescribed exercise, which relates to the changes in consensus guidelines and clinical practice of athletic trainers and physicians during the five-year data collection period. As such, the physical activity groups examined were not equally represented, with the Non-ERx group having the

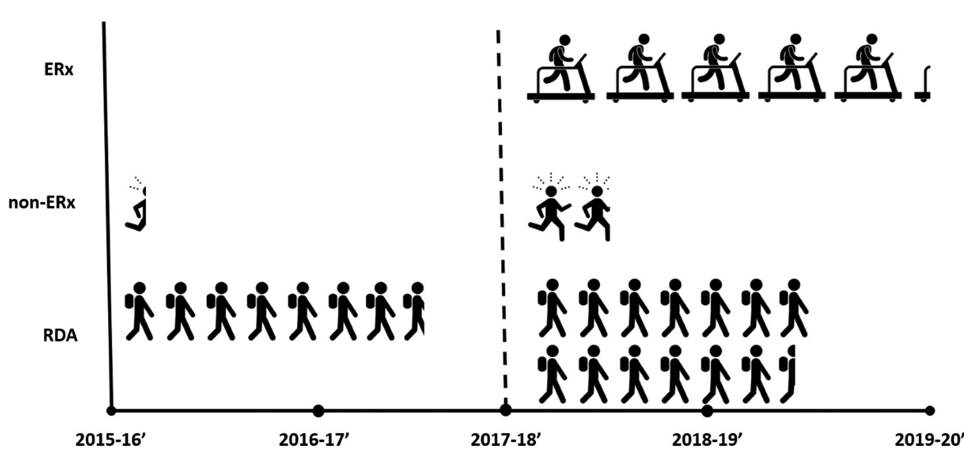

Figure 3. A depiction of the number of athletes who were prescribed exercise (ERx), physical activity without a specific prescription (non-ERx), or routine daily activities (Rda)s before and after 2017. Each figure represents 10 participants.

least representation among the groups. In addition, we did not collect data regarding specific FITT exercise prescriptions and the timing of their implementation (e.g., immediately versus in response to lingering symptom experiences). Therefore, it is possible that some overlap existed between our groups. It should also be acknowledged that exercise prescription may be unique to different sports and athlete profiles which also warrants investigation in order to provide patient-centric prescriptions. Future research should examine the specific FITT prescription following concussion to confirm and/or extend our findings. Finally, future investigations should determine how exercise following concussion may alter physiological and psychological measures of recovery to holistically determine readiness to RTS.

Conclusions

Exercise that is not prescribed using clear and standardized guidelines, (i.e., FITT prescription) may cause longer recovery timelines after concussion in collegiate athletes and may need to be avoided. While well-intentioned, an informal approach to early exercise post-concussion may inadvertently cause more harm than good by impeding SR. Therefore, if exercise is encouraged for patients following concussion, it should be prescribed and monitored closely to ensure more adaptive patient outcomes. If exercise cannot be prescribed and monitored, RDAs may be recommended. More research is needed to specify the appropriate dosing and type of exercise that is optimal for rehabilitation following concussions in collegiate athletes.

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