Rehearsal and Performance Volume in Professional Ballet: A Five-Season Cohort Study

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ABSTRACT

Introduction: Few studies have published data concerning the longitudinal rehearsal and performance demands experienced by professional ballet dancers. We aimed to describe the rehearsal and performance volumes undertaken across five professional ballet seasons, and identify factors associated with inter-dancer and inter-production variation in dance hours.

Methods: Scheduling data were collected from 123 dancers over five seasons at The Royal Ballet. Linear mixed effects models were used to evaluate differences in: i) weekly dance hours and seasonal performance counts across sexes, company ranks, and months, and ii) factors associated with the variation in rehearsal hours required to stage different productions.

Results: On average across the five seasons, a peak in performance volume was observed in December, whereas rehearsal hours peaked in October and November, and between January and April. Differences in weekly dance hours were observed between company ranks ($p < .001$, range in means: 19.1–27.5 $h \cdot week^{-1}$). Seasonal performance counts varied across company ranks ($p < .001$), ranging from 28, 95% CI [22, 35] in principals, to 113, 95% CI [108, 118] in the rank of artist. Rehearsal durations were considerably greater in preparation for newly created ballets compared with existing ballets (77.8 vs 37.5 h). Rehearsal durations were also greater in preparation for longer ballets, with each additional minute of running time associated with a 0.43 h increase in rehearsal duration ($p < .001$). Full-length ballets, however, were consistently the most time-efficient to stage due to their long performance runs compared with shorter ballets (16.2 vs 7.4 performances).

Conclusions: Training principles such as progressive overload and periodization should be implemented in professional ballet companies to manage the high and variable rehearsal and performance loads.

Keywords: Dance; Periodization; Training Load; Athlete Monitoring; Injury and Prevention

Key Points:

- Rehearsal and performance volumes in professional ballet are high and fluctuate greatly from week-to-week; healthcare practitioners and artistic staff should implement training principles (e.g., progression, periodization) to manage these demands.
- The rehearsal hours completed in preparation for different productions varied widely; consideration of these rehearsal hours could inform casting and repertoire planning, and subsequently optimize scheduling.
- Full-length existing classical ballets were the most time-efficient productions to stage and may provide a means by which rehearsal volume may be offloaded during the season. Newly created ballets were the least time-efficient to stage.

INTRODUCTION

To provide effective support services to dancers, science and medicine practitioners must understand the physical demands undertaken by those dancers.[1] The acute activity demands of ballet have been relatively well described; ballet is intermittent,[2] with an activity profile comparable to basketball[3] and tennis.[4] Performances are comprised of short durations of high-intensity movement interspersed with periods of low-intensity activity, during which a dancer may be in character or off-stage.[5] Within a performance, dancers are required to execute highly technical jumps, lifts, and balances, requiring strength, power, flexibility, and motor control.[6] The demands of a ballet schedule over months and years, however, have not yet been explored.

To date, no study has investigated the rehearsal or performance schedules of a professional ballet company beyond a three-week period. Several studies report superficial descriptive data regarding the structure of a ballet schedule: companies perform ~145 shows per season, comprised of ~15 different productions, and weekly dance hours are between 30–40 h.[7] It is unclear, however, in how many of these shows individual dancers perform, in how many of the productions individual dancers are cast, and how much intra-individual, inter-individual, and seasonal variation in dance hours exists. Furthermore, no study has investigated the rehearsal periods required to stage specific productions, nor the factors which may influence these rehearsal periods.

Two position stands and consensus statements have been published relating to longitudinal workload in sport, and its relationships with performance, overtraining, injury, and illness.[8,9] In sport, fundamental training principles are employed to optimize training outcomes.[10] Despite suggestions that ballet, like sport, should embrace established training principles such as periodization[11] and progressive overload,[12] the absence of published longitudinal data relating to the structure of a ballet season makes it challenging to implement these strategies. In the present study we explore a five-year data set of the ballet class, rehearsal, and performance

exposure scheduled by an elite professional ballet company. Measures of exposure, although lacking a measure of intensity, have been shown to be important variables to monitor in sport,[13–15] whilst excessive week-to-week changes in dance exposure have been associated with injury risk in professional ballet.[12]

The first aim was to describe the volume of rehearsal and performance completed by professional ballet dancers across five seasons. The second aim was to identify factors related to the variation in rehearsal hours across different productions.

METHODS

Participants

The initial sample were 124 dancers of The Royal Ballet; 108 gave written informed consent, one declined, and 15 did not respond. To use anonymized data pertaining to the 15 participants who could not be contacted, a legitimate interest assessment was completed to ensure data protection regulations were met, following which written support from both the Data Controller and Clinical Director of the company was provided. This was approved by the local ethics committee in accordance with the Declaration of Helsinki. A total of 123 dancers (women: n = 66, 28.0 ± 8.3 y; men: n = 57, 27.9 ± 8.5 y) were therefore included in this study.

All company members are assigned a rank. The rank of apprentice indicates the dancer is in their first year of professional ballet. Dancers may then be promoted through the ranks of artist, first artist, soloist, first soloist, and principal, performing increasingly featured roles as their seniority increases. One additional rank, principal character artist, is given to older company members who perform less physically demanding character roles. A breakdown of the distribution of company ranks across each of the five seasons is presented in Table 1.

Table 1 Company demographics for each season. Numbers in brackets indicate the count of dancers who were not included in the study.

Demographic	2015/16	2016/17	2017/18	2018/19	2019/20
All	88	91	90	99	99
Female					
Apprentice	2	4	3	4	4
Artist	11	11	10	14	12
First Artist	9	10	11	10	12
Soloist	11	9	8	4	5
First Soloist	7	7	6	9	9
Principal	6	8	8	8	8
P.C. Artist[A]	2	1	3	3	3
Male					
Apprentice	3	4	4	4	2
Artist	7	7	7	10	11
First Artist	5	6	6	7	7
Soloist	8 (1)	7 (1)	7	7	8
First Soloist	7	5	4	5	5
Principal	7	9	8	9	8
P.C. Artist[A]	3	3	5	5	5

[A]P.C. Artist – Principal Character Artist

Design

We used a descriptive cohort design to explore the structure of a professional ballet season, using data collected for a larger prospective study.[16] Ballet classes, rehearsals and performances taking place at the Royal Opera House, London, were prospectively recorded as part of normal working practices between the 2015–16 and 2019–20 seasons.

Data Collection

Three session types were included in this study: *Class* – typically the first session of a dancer's day, focusing on ballet technique; *Rehearsal* – a session during which dancers will be learning or practicing choreography for a specific ballet; and *Performance* – a single show on the main stage for which a public audience is present. Throughout this study the term Production is also used, referring to the ballet being performed (e.g., Romeo and Juliet, The Nutcracker, etc.).

Class and rehearsal data were recorded by the company's Artistic Scheduling Manager. Data were entered once a week using a bespoke athlete management system (Smartabase, Fusion Sport, Brisbane, Australia). Performance data were recorded using casting sheets; both electronic and hard copies were filed following each performance. It was beyond the scope of the available data to determine the exact duration for which each role was involved in a performance; as a result, dancers were assigned 3 h of exposure time—the duration for which they are scheduled to be in attendance. Scheduling data for touring periods were incomplete, and were therefore excluded from this study. Touring periods were typically 4 weeks in duration during June and July, immediately following the conclusion of the 2015–16 to 2018–19 seasons.

Throughout the data collection period, time-loss injury data were recorded to the athlete management system by in-house Chartered Physiotherapists. For analyses of weekly dance hours and week-to-week changes in dance hours, data points were removed from the analysis when the dancer was designated as injured for more than two days in a week. For seasonal performance counts data points were removed from the analysis when the dancer was designated as injured for more than 10% of days during the season. These decisions were made such that data reflected the demands of an uninjured dancer's schedule.

Data Processing

Following the conclusion of the 2019–20 season, all scheduled class and rehearsal data between 4th August 2015 and 15th March 2020 were exported from the athlete management system. Performance involvements were determined by manual inspection of hard copies of casting sheets, ensuring all last-minute casting changes were accounted for. Neither electronic nor hard copies of casting sheets were available for 8 performances (1.2% of all performances). No action was taken to impute data. Scheduling data were subsequently used to calculate the

summary variables, defined in Table 2. For seasonal performance counts, data from the 2019–20 season were excluded from the analysis due to being cut short because of the COVID-19 global pandemic.

Table 2 Definitions of calculated variables

Variable	Definition
Weekly dance hours	The sum of scheduled dance hours in a dancer-week.
Seasonal performance count	The count of performances in a dancer-season.
Week-to-week change	The difference in a dancer's weekly dance hours compared to the previous week.
Individual rehearsal hours	The rehearsal hours completed by a dancer in preparation for a specific production.
Company rehearsal hours	The total rehearsal hours completed by all dancers in preparation for a specific production (i.e., the sum of individual rehearsal hours for a given production).
Production time-efficiency	The ratio of company rehearsal hours to the total on-stage performance time resulting from the production (i.e., company rehearsal hours / [number of performances × performance duration]).

Statistical Analysis

To investigate differences in weekly dance hours across sexes, company ranks, and months, and differences in seasonal performance counts across sexes and company ranks, linear mixed effects models were implemented using the *lme4* R package.[17] Sex, company rank, and month were entered as fixed effects, whilst within-individual grouping and season were entered as random effects. Bonferroni adjusted pairwise comparisons of estimated marginal means were used to compare differences across sex, rank, and month. Significance was accepted at $p < .025$, accounting for two primary outcomes.

To investigate factors associated with the individual rehearsal hours required to stage a production, a linear mixed effects model was used. Dancer (company rank, sex, performance count) and performance characteristics (production running time, years since last staged,

existing ballet or newly created choreography) were entered as fixed effects, whilst within-individual grouping and production were entered as random effects. Where significant effects were observed, estimated marginal mean rehearsal hours were extracted from the model and compared graphically.

For each model, the assumptions of normality, linearity, and homoscedasticity were confirmed. Data are reported as mean ± SD. Data processing and analyses were conducted using R v.4.0.3 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

All seasons ran from August to June, except for 2019–20 which concluded prematurely in March due to the COVID-19 global pandemic. Touring periods immediately followed the final week of each season (mean duration 28 ± 4 days). A representative timeline of a season is shown in Figure 1. The company staged 10.5 ± 0.8 (range: 9–11) productions per season, comprised of 18.3 ± 1.6 (range: 16–20) separate ballets. The company performed totals of 133, 135, 138, 132, and 94 (+43 cancelled) shows in the 2015–16 to 2019–20 seasons, respectively. Ninety-eight out of 365 dancer-seasons and 1,767 out of 15,837 dancer-weeks were removed from the analysis due to injury.

The mixed effects model investigating weekly dance hours revealed significant main effects of company rank ($p < .001$; Figure 2-A), month (Figure 3; $p < .001$), and company rank × month interaction ($p < .001$), but no effect of sex (female 22.8 h, 95% CI [22.0, 23.6]; male 23.9 h, 95% CI [23.1, 24.7]; $p = .049$) or sex × company rank interaction ($p = .348$). The mixed effects model investigating seasonal show count revealed a significant main effect of company rank ($p < .001$; Figure 2-B), but no effect of sex (female 73.5 shows, 95% CI [69.5, 77.4]; male 76.2 shows, 95% CI [72.3, 80.1]; $p = .338$), or sex × company rank interaction ($p = .689$). The

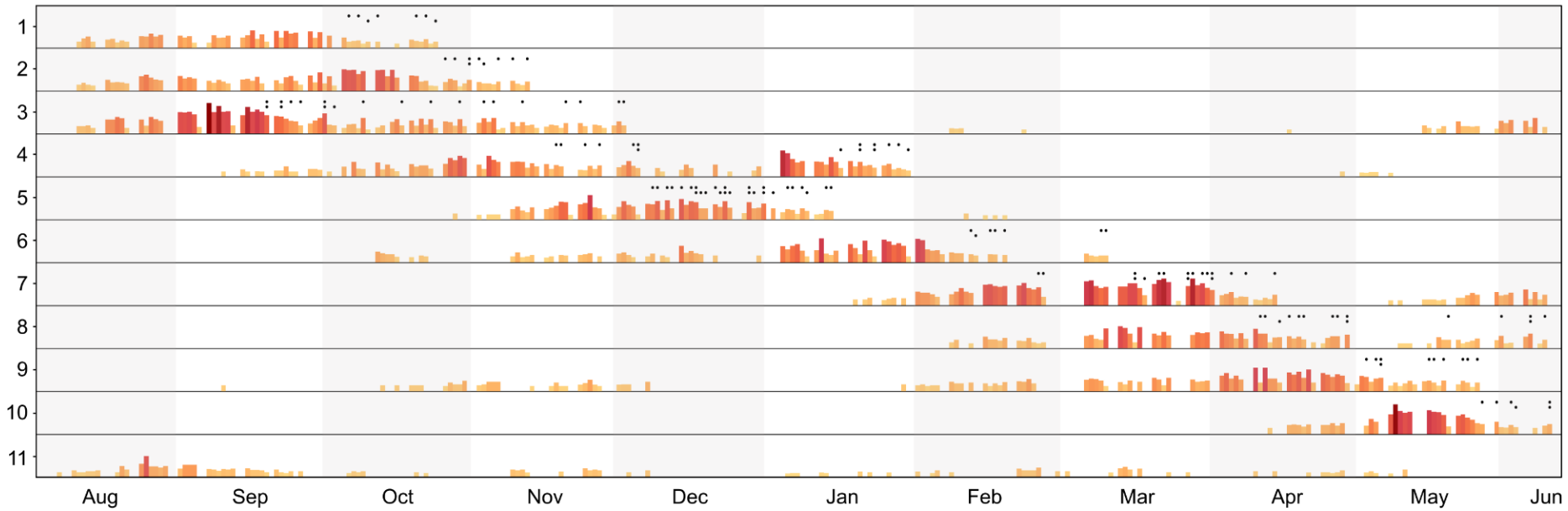

Figure 1 A representative season timeline (2015/16) showing each production on the y-axis, and the time course of the season on the x-axis. Column height and darkness represent the daily rehearsal time for the production, whilst lower and upper dots indicate matinees and evening performances, respectively. The end of the season was immediately followed by a four-week touring period. Productions: 1–Raven Girl/Connectome; 2–Quadruple Bill; 3–Romeo and Juliet; 4–Triple Bill; 5–The Nutcracker; 6–Triple Bill; 7–Giselle; 8–The Winter's Tale; 9–Frankenstein; 10–Triple Bill; 11–Non-main rep.

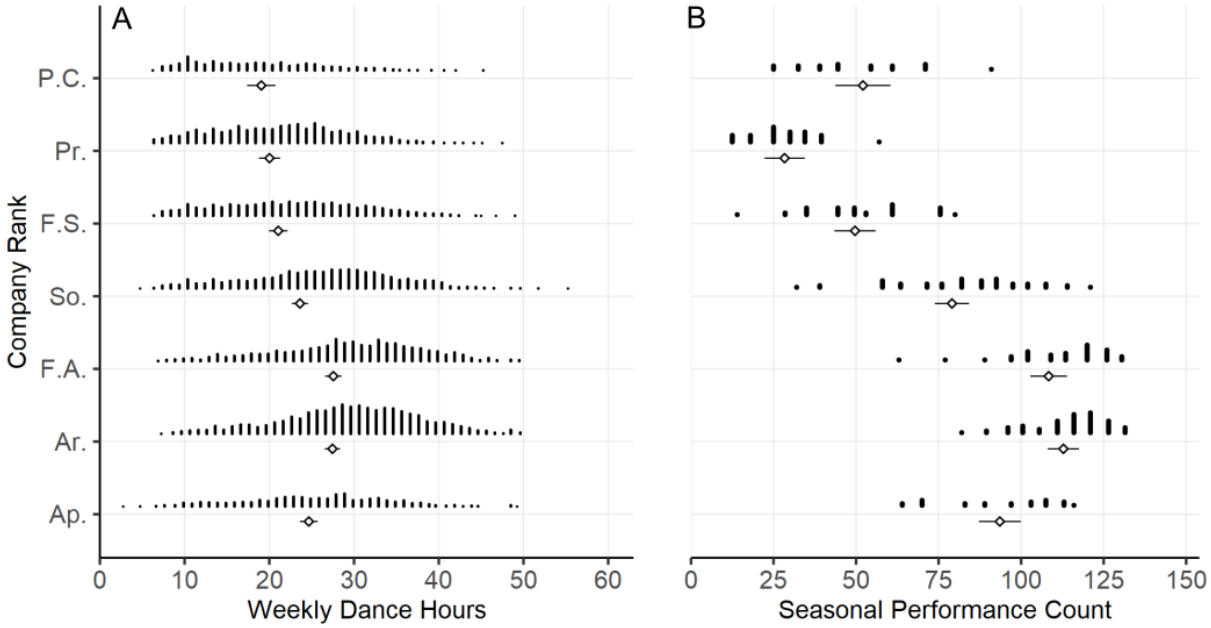

Figure 2 A) Weekly dance hours and B) seasonal performance counts, by company rank. Diamonds and bars indicate the estimated marginal mean and 95% confidence intervals extracted from mixed effects models. Ap. – apprentice; Ar. – artist; F.A. – first artist; So. – soloist; F.S. – first soloist; Pr. – principal; P.C. – principal character artist.

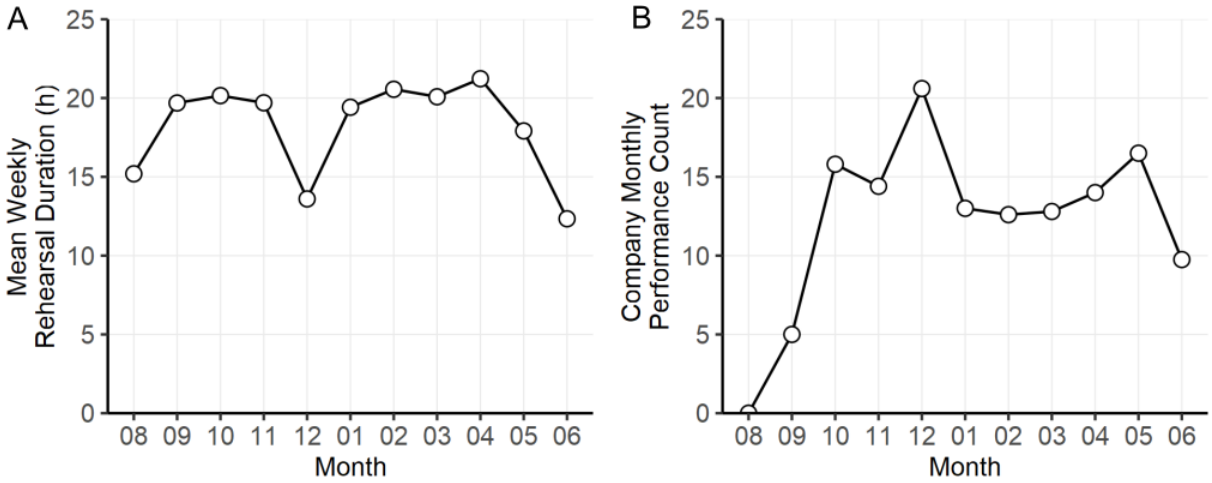

Figure 3 A) Mean weekly rehearsal hours and B) total number of performances staged by the company for each month in the season.

distribution of increases in week-to-week change in weekly dance hours across all recorded dancer-weeks is presented in Figure 4.

The individual rehearsal hours, company rehearsal hours, and production time-efficiency for all productions staged across the five seasons are presented in Supplementary Material 1. The mixed effects model investigating factors associated with individual rehearsal hours revealed significant main effects of: years since the production was last staged ($p < .001$); production duration ($p < .001$); and an interaction effect of company rank × new or existing ballet ($p < .001$), but no association was observed with sex ($p = .119$) or the number of performances of the production completed by the dancer ($p = .960$). The mean individual rehearsal hours associated with each significant independent variable is presented in Figure 5.

DISCUSSION

This study explored five seasons of rehearsal and performance scheduling data at a professional ballet company; this is the first study investigating the longitudinal working demands of a professional ballet company for a period beyond three weeks. Mean weekly dance hours were between 19.1 and 27.5 h, though weeks involving > 40 h of scheduled dance were common; large variations in weekly dance hours were evident both between and within company rank and month of the season. Alongside this study we provide company rehearsal durations for specific productions, and the time-efficiency of those productions. Dancers involved in newly created ballets appear to complete considerably more rehearsal than they might in an existing work, warranting offload from other productions. These results are the first to investigate the structure of a ballet season, and may be useful for staff when periodizing repertoire, casting productions, or planning late-stage rehabilitation for dancers following injury.

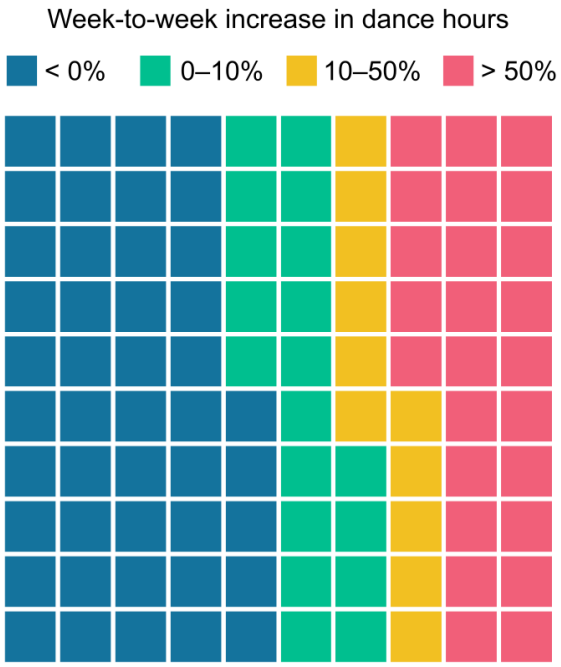

Figure 4 Week-to-week increases in dance hours across the company. Each square represents 1% of dancer-weeks in the dataset.

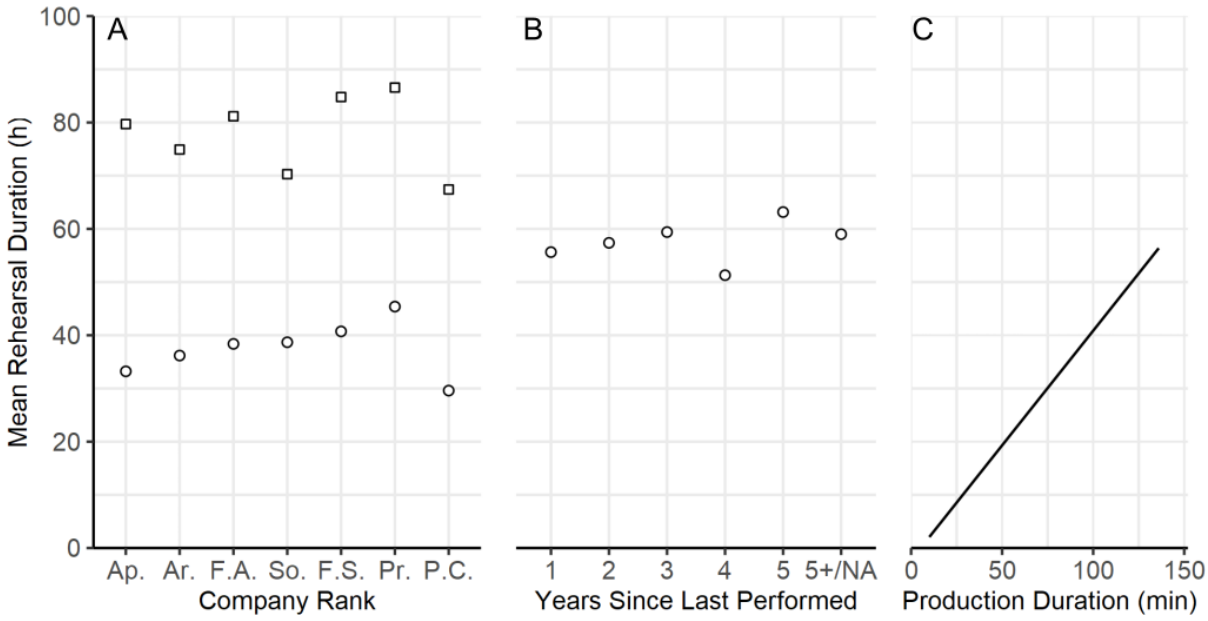

Figure 5 Associations between A) company rank, B) the number of years since a production was last staged, or C) the running time of a performance, and the mean rehearsal duration completed by a dancer in preparation for a production. In panel A, squares represent new ballets, whilst circles represent existing ballets. Ap. – apprentice; Ar. – artist; F.A. – first artist; So. – soloist; F.S. – first soloist; Pr. – principal; P.C. – principal character artist.

We observed mean weekly dance hours between 19.1 and 27.5 h, exceeding training and competition durations reported in elite rowing,[18] rugby union,[19] and track and field.[20] Whilst it is important to acknowledge that the present data lacks a measure of intensity, and is therefore not a comprehensive measure of training load, the extent to which these values exceed those in sporting contexts is notable. Even the highest daily durations reported in sport[18–20] fall at the lower end of those observed in the present study. These dance volumes likely underpin the reduction in physical performance observed at the conclusion of a ballet season,[21] and the high rate of burnout in classical dance.[22] Large variation in weekly dance hours was evident across the cohort; the 'worst-case-scenario'[23] for a dancer may therefore be ~50 h of scheduled dance in a week. In a rehabilitation context, medical staff should consider whether a dancer is prepared to tolerate this volume of work before returning to full rehearsal. In the present cohort, we have previously demonstrated increases in injury risk with greater progressions in training volume.[12] The frequency of large week-to-week increases in dance hours should therefore be a cause for concern;[24,25] this is particularly the case as we believe it would be unlikely for intensity to be adjusted in response to increases in exposure. In keeping with well-established principles of training, ballet companies should avoid scheduling large spikes in rehearsal and performance volume where possible.

We observed large variations in weekly dance hours both within, and between company ranks. As dancers are promoted from apprentice through the ranks of artist and first artist, greater weekly dance durations and seasonal show counts are evident. As dancers are promoted beyond the corps de ballet, however, dance volume is reduced. Junior company members, however, have previously been shown to spend less time active across the day compared with soloists and principals.[26] Thus, it seems probable that as a dancer's rank progresses, their volume of work decreases whilst the intensity of their work increases.[5] The transition from pre-professional to professional ballet has been identified as a potential period of heightened injury

risk due to increased ballet exposure.[27] However, we observed similar weekly dance hours in apprentices as those previously reported in pre-professional dancers,[28] suggesting this transition does not represent an increase in dance exposure. No difference in dance hours was observed between sexes. Scheduled dance time therefore appears to be broadly comparable between male and female dancers, though in specific companies, and at specific timepoints, these values are likely to fluctuate based on the repertoire, casting, and company demographic.

Ballet exposure and performance frequency fluctuated across the course of each season. The relatively low dance exposure recorded in September reflects the absence of performances, as well as efforts to incrementally increase load in response to research identifying this period as one of heightened injury risk.[29] Despite the increase in show count, December sees a reduction in dance hours across all company ranks. This reflects the staging of *The Nutcracker* in four of the five seasons, a production which is highly time-efficient. Thus, a regular and well-established ballet requiring relatively little rehearsal, in combination with a long performance run, may be a useful tool by which to de-load rehearsal volume. Dance volume was highest in October and November, and from January to April. These months likely reflect 'normal' in-season volumes, compared with the 'low' months discussed above.

For the first time, we have investigated the duration of rehearsal completed in preparation for individual productions, and explored factors associated with the variation in these durations. Whilst it is unsurprising that greater rehearsal hours were observed in preparation for longer productions, full length productions were in fact time-efficient to stage, primarily due to the large number of performances which took place during runs of those productions compared with shorter ballets (16.2 vs 7.4 performances per production). Newly created ballets were typically the least time-efficient to stage, reflecting the additional time required to choreograph and subsequently learn the production. It is evident from the individual rehearsal hours completed in preparation for a newly created ballet that individuals involved in the creation of

a ballet complete greater volumes of rehearsal. Consideration should be given to the concurrent roles in which these dancers are cast; where possible, companies should consider offloading other roles to ensure their work is manageable. Finally, despite their lower weekly dance hours, senior-ranking dancers typically complete greater rehearsal hours than junior-ranking dancers for individual productions (Figure 5); their lower weekly ballet exposure is therefore a result of being cast in fewer productions.

Practical Applications and Recommendations for Future Research

In line with previous recommendations, the present results provide a basis for the periodization of rehearsal and performance volume throughout a professional ballet season.[30] For example, specific applications of these results include: providing periods of volume offload by scheduling time-efficient productions amongst inefficient ones; forecasting the required rehearsal hours of a production to facilitate a gradual progression in ballet volume in advance of the start of rehearsals; planning an incremental return-to-dance during rehabilitation; and periodization of the repertoire to avoid periods of rehearsal and performance congestion.

Several specific ballets warrant discussion. Firstly, full-length classical ballets such as *The Nutcracker, Romeo and Juliet, Manon* and *The Sleeping Beauty* were highly time-efficient to stage due to their long performance runs, and frequent appearances season-to-season. To this end, even full-length new creations such as *Swan Lake* and *Frankenstein*, which incurred by far the largest company rehearsal hours, were relatively time-efficient to stage because of their long performance runs. Mixed bills comprised of several shorter ballets typically required the most rehearsal hours relative to the resulting performance time. In the instance that one of those shorter ballets is a new creation, an effort should be made to account for the resulting increase in rehearsal volume by pairing it with more time-efficient productions.

Further research into the scheduling demands—or better still, the training loads—experienced by professional ballet dancers at other dance companies or schools may be beneficial for science and medicine practitioners seeking to optimize rehearsal and performance schedules. In particular, this may be useful for touring companies which operate under separate rehearsal and performance periods,[7] or for ballet schools, wherein the demands experienced by a student may change year-on-year.

Strengths and Limitations

Strengths of this study include the five-year dataset; the entry of all class and rehearsal sessions by a single individual; the use of a standardized entry form to record class and rehearsal data; and the high availability of casting sheets. Several limitations of the data should be acknowledged. Firstly, the study is limited by a lack of an intensity measure, therefore we cannot fully understand workload across this period. Although data describing both the volume and intensity of activity are commonplace in sporting research, this level of data is not yet routinely collected in professional ballet companies due to the large number of dancer, limited resources, cultural challenges, and individualized schedules. The present data therefore represents a considerable progression in the quality of longitudinal data in this field. There was no register of attendance taken at rehearsals—we believe it is unlikely though, that dancers would not have attended rehearsals for which they were scheduled. It was beyond the scope of the available data to break down every individual performance role across the study period. We therefore could not ascertain a dancer's level of involvement within a show, or within specific productions in a mixed bill. Finally, the lack of scheduling data during touring periods is a limitation, as this represents a considerable volume of rehearsal and performance.

It is important to note that differences exist between companies in the rehearsal and performance schedule structure, and the casting of productions. Science and medicine

practitioners working in professional ballet should therefore consider the degree of similarity between companies when applying these results.

CONCLUSION

Over a five-season period in a professional ballet company, large and variable rehearsal and performance volumes were observed. Artistic staff and science and medicine practitioners should be mindful of large week-to-week variability in dance hours, the high volumes of work associated with new productions, and congested periods of dance exposure in the latter stages of the season. Training principles such as periodization and progression should be implemented to manage these demands. Absolute and relative rehearsal and performance volumes should be considered when planning repertoire, casting ballets, and scheduling rehearsals and performances.

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SUPPLEMENTARY MATERIAL

Supplementary Material 1 Rehearsal characteristics for each production staged.