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1 **Title: Injuries across a pre-professional ballet and contemporary dance tertiary training**
2 **program: A retrospective cohort study**

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24

25 **Abstract**

26 Objective: The study aims to analyse the incidence of medical attention injuries, subsequent injuries,
27 and the median time to injury, across tertiary ballet and contemporary dance training programs.

28 Design: Retrospective cohort.

29 Methods: Consenting ballet and contemporary dance students completing the third/final year of two
30 tertiary programs were included. The three-year programs consisted of six semesters. Access was
31 granted to onsite physiotherapy notes, timetables, and academic enrolment. Injury was defined as
32 requiring medical attention. Injury and exposure data were extracted, injuries coded for location and
33 tissue, and subsequent injuries, occurring after an initial index injury, categorised. Mean, standard
34 deviation, range, injury incidence, risk and rate ratios, proportions and Kaplan-Meier curves were
35 calculated to report participant characteristics, and injury patterns across three years of the dance
36 program.

37 Results: All 17 students (mean age=20.7 years; standard deviation=1.32) from one program consented
38 to participate, of which all were injured across the three-year program, with 2.71 (95% confidence
39 interval: 2.22, 3.20) injury incidence rate per 1000 hours, and increasing injury incidences seen across
40 the program. The most injured site and tissue were the ankle (17.65%) and muscle (23.53%)
41 respectively. 74.86% of subsequent injuries were different (affecting a different location and tissue),
42 and 4.88% reinjuries (affecting the same location, tissue, and structure after recovery). The median time
43 to the first injury was seven weeks in the first semester, and later in subsequent year levels.

44 Conclusions: Increasing injury incidences were seen across the program. Most subsequent injuries were
45 different from previous injuries in this cohort. Future research should use exposure measures beyond
46 hours (i.e. intensity) and consider subsequent injuries.

47 Keywords: dance, injury, prevention

48 **Practical Implications**

- 49 • Fifty percent of participants were injured by the end of the seventh week in the first and second
50 semesters of the program.
- 51 • A trend of increasing injury incidence can be seen to progress across the program.
- 52 • Most subsequent injuries affected a different location and tissue, suggesting injury
53 rehabilitation strategies should be directed beyond the injured location and tissue.
- 54 • Injury reduction strategies implemented early in the program may have a positive influence on
55 the time to first injury, increasing injury incidences, and subsequent injuries as students'
56 progress through their training.

57 **1.0 Introduction**

58 Elite amateur contemporary dance students (age: male 18.8 years, female 19 years) are known to
59 experience high training loads¹. In the cohort investigated by Jeffries et al.¹, training is prescribed by
60 the school director and choreographers, with three to four daily classes or rehearsals (mean
61 contemporary class duration 91.5 ± 19.7 minutes; mean rehearsal duration: 137.5 ± 45.7 minutes), of
62 low to moderate intensity, with periods of high intensity activity¹. Similarities exist between ballet and
63 contemporary dance, with both utilising class for skill acquisition, rehearsal for performance
64 preparation, and a period of stage performance².

65 The majority of injuries in ballet dancers of all ages and levels are of an overuse nature³. The prevalence
66 of injury in pre-professional dance is high, with 82.4%⁴ (age range: 11-30 years) and 86.2%⁵ (age range:
67 16-24) reported in combined ballet and contemporary dance cohorts. Understanding risk factors for
68 injury can guide injury prevention strategies. A history of injury is known to be a risk factor for future
69 injury in pre-professional ballet and modern dance⁶, and the number of previous injuries in ballet
70 dancers of all levels⁷. Accordingly, it is of value to consider when dancers get injured more than once,
71 how injuries relate to each other, and their relationship to training.

72 To consider the number of injuries recorded, beyond the proportion of dancers injured, reveals
73 important findings for pre-professional dancer's susceptibility to injury in different year levels of
74 training⁸. Thus, understanding subsequent injuries⁹, injuries sustained after an initial index injury, may

75 further guide cost-effective injury reduction interventions. Year levels could be considered as subgroups
76 in pre-professional dance populations. Group-based injury reduction interventions can be cost-
77 effective¹⁰ and have been shown to reduce injury occurrence by 30% in soccer players over 13 years
78 old¹¹. Perhaps group-based injury reduction interventions, directed towards year levels in pre-
79 professional dance, may be of use in reducing injuries.

80 A systematic review⁸ identified two studies considering the relationship of injury to year levels during
81 full-time pre-professional training. Ekegren et al.¹² demonstrated injury rates to rise across the three-
82 year levels in pre-professional ballet students. Alternatively, Lee et al.⁵ observed injury rates to be
83 highest in the first year of study in ballet and contemporary dance students. In ballet students, 14% of
84 all injuries were reinjuries¹² (the same injury recurring after recovery), with a lower proportion of
85 injuries being reinjuries reported in ballet and contemporary students⁵. Lee et al.⁵ commented that using
86 the Subsequent Injury Categorisation (SIC)¹³ model, to take into account within-person subsequent
87 injuries, updated to an eight category framework⁹, may help to understand the relationship between
88 injuries in dance to guide tertiary injury reduction.

89 Understanding the temporal nature of injuries across participation in a tertiary dance program can show
90 when dancers negatively adapt to training and guide injury reduction strategies. There have been no
91 studies undertaken in pre-professional dance contexts investigating participation across an entire dance
92 training program. Beyond considering which year levels have an increased susceptibility to injury, the
93 timing of injury within semesters of training could further guide when to direct injury reduction
94 strategies.

95 This study aims to analyse medical attention injuries across participation in a three-year tertiary ballet
96 and contemporary dance training program. The study will compare differences between injury
97 incidences for each semester of the program (considered as training blocks), categorise subsequent
98 injuries, and consider the median time to injury across the program.

99 **2.0 Methods**

100 2.1 Study design, setting, and participants

101 A convenience sample of final-year tertiary students in a dance program, training in ballet and
102 contemporary dance, were approached after their training to participate in a three-year retrospective
103 cohort study. All participants approached were in their final year of study within one of two, three-
104 year dance training programs (performance and education). One program was directed at
105 performance, the second at dance education. Both programs included a four-week training program at
106 the commencement of the first semester, before beginning an ongoing training timetable. The
107 timetable of the dance performance program consisted of approximately 30 hours of dance and
108 physical training per week across a 14 to 15-week semester, with a one-week mid-semester break for
109 the dance performance program. The second program had less dance and physical training hours.
110 Each academic year consisted of an approximate six-week break between the two semesters, and
111 three-and a half-month break at the end of each year where no formal training was scheduled. The
112 final semester of the third year of the dance performance program commenced with an international
113 study tour, extending the second semester by three weeks for some participants and included training
114 and performances. Written informed consent was requested to access data for analysis, to be further
115 described. The University Human Research Ethics Committee approved this study (approval number
116 1600000953). The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology)
117 guidelines¹⁴ were followed for this investigation.

118 2.2 Variables and data sources

119 Injury data were extracted from hardcopy physiotherapy notes made predominately by a postgraduate
120 qualified physiotherapist, with nine years' experience in dance. Injury was defined as requiring medical
121 attention⁴. Injuries related to dance participation were diagnosed by the same onsite physiotherapist
122 following a complimentary clinical assessment. Consultations were aimed at initial assessment and
123 advice, not ongoing management. Time loss (TL) injuries requiring 24 hours or more cessation of dance
124 activities were considered separately¹⁵. A unique injury episode was recorded if there was a report of
125 exacerbation or worsening of symptoms, regardless of recovery of an ongoing condition. Injury
126 recovery was defined by subjective report that the injury had resolved, extracted from the physiotherapy
127 notes upon subsequent presentations to the onsite physiotherapist. Given that the nature of the clinic

128 was directed at initial assessment and advice, not ongoing management, injuries were not tracked to
129 recovery beyond report at subsequent physiotherapy consultations. Subsequently, recovery was
130 considered to have occurred by the next semester following a holiday period. Data were extracted from
131 records, and de-identified for dance injury surveillance analyses. Data were then categorised and coded
132 as per the following:

- 133 • Outcome variables: week of injury across the program¹⁶, both reported onset and when
134 presented to physiotherapy from physiotherapy records;
- 135 • dance-related injuries, sequenced temporally¹⁶, given a four-character Orchard Sports Injury
136 Classification System (OSICS) version 10.1¹⁷ code, and a SIC version 2.0⁹ (SIC-2.0) code by
137 a coder with a clinical background (MF), non-program related injuries were excluded;
- 138 • side of injury;
- 139 • whether investigations or referral to other medical practitioners was recommended;
- 140 • whether the injury required participation modification (continued participation in dance
141 activities, with restrictions applied) or TL¹⁵;
- 142 • whether the mechanism of injury was traumatic or overuse; and
- 143 • Exposure variables: dance hours each week from enrolment and timetables, to determine which
144 courses participants were enrolled in and how many hours were involved respectively.

145 2.3 Statistical methods

146 Participant characteristics were summarised using means, standard deviation (SD), and range, with no
147 exclusion criteria applied. Injury incidence rates per 1000 hours (number of injuries per exposure hours)
148 and 95% confidence intervals (CI)¹⁸ were calculated per semester of the program, as well as for the
149 entire program. The number of injuries was determined from extracted data from physiotherapy notes
150 as stated above, with the timing of injury determined by the reported week of onset of injury from the
151 physiotherapy records, and which semester the injury occurred in determined. The hours of exposure
152 were determined from enrolment and timetables as stated above. Risk (RiR) and rate (RaR) ratios were
153 used to compare injuries for each semester relative to other semesters combined¹⁸.

154 Proportions were calculated for each SIC-2.0⁹ category. All subsequent injuries per participant were
155 categorised relative to each preceding injury (i.e. the first subsequent injury would have one assigned
156 category, the second subsequent injury would have two assigned categories, and so forth). From these,
157 proportions were determined of the number assigned to each category of interest compared to the
158 number of all assigned subsequent injury categories across all participants. The first two characters of
159 the four-character OSICS code¹⁷ that indicate the anatomical area, and tissue type, were used to
160 calculate the injury proportions for anatomical location and tissue type. The data were analysed using
161 MS Excel v1706 (Microsoft Corporation, Redmond, USA). The first injury recorded for each
162 participant was referred to as the ‘index’ injury and did not receive a SIC-2.0 category and was given
163 an OSICS code. The reported week of injury onset was used to determine the time to initial injury for
164 each semester, also considered a subsequent injury if after the index injury and given a SIC-2.0 category.
165 The reported week of injury was used to calculate the time to subsequent injuries within each semester.
166 Kaplan-Meier curves¹⁹ were used to estimate the median time to the first injury to commence each
167 training semester across the program with 95% CI using IBM SPSS statistics software (version 24,
168 SPSS, Inc, Chicago, USA). When the proportional hazards assumption that the proportional hazards
169 stay constant over time²⁰ was met, a Log-Rank test was used²¹ to compare survival curves between two
170 groups for each variable^{20 22 23}. When the assumption was not met, the Breslow test was used^{24 25}.
171 Statistical significance was set at $P < 0.05$.

172 **3.0 Results**

173 3.1 Participant characteristics

174 Seventeen dance students consented to participate from the performance program (100% participation;
175 mean age to complete program 20.7 years; SD=1.32; range=19-25; 16 female, 1 male). These
176 characteristics are considered to be representative of tertiary dance cohorts, with gender differences
177 often skewed. There were no consenting participants from the dance education program. This program
178 will not be discussed further. The three-year performance training program involved six semesters,
179 during which 119 injuries were recorded.

180 3.2 Injury incidence

181 Medical attention injury incidence per 1000 hours was 2.71 (95% CI: 2.22, 3.20; Figure 1), and the TL
182 injury incidence per 1000 hours was 0.07 (95%CI: -0.01, 0.15). Risk ratio and RaR with 95% CI were
183 calculated for each semester, relative to other semesters combined (Table 1).

184 3.3 Injury characteristics

185 Three of the 119 injuries required TL for two students. Thirteen injuries (11%) required referral for
186 investigation or to see an external practitioner, beyond physiotherapy management. Sixty-seven injuries
187 (56%) required training modification, and seven injuries (6%) were traumatic. One student deferred
188 their studies in the second semester; the reason for deferral is unknown. All students had at least one
189 injury recorded (range=1-14), with 54% of injuries recorded for five participants. The ratio of injuries
190 right:left was 1.19, with three injuries considered to be central. The average time to present to
191 physiotherapy from the reported time of onset was 1.14 weeks (SD=1.29; range=0-7 weeks). The most
192 common injury location was the ankle (17.65%), then knee (16.81%), and hip (13.45%). The most
193 common injured tissue was muscle (23.53%), followed by impingement/bursitis/synovitis (21.01%),
194 then tendon (16.81%).

195 3.4 Subsequent injuries

196 Injuries that were at a different site and of a different nature (SIC-2.0 category VIII) represented 74.86%
197 of subsequent injuries. The smallest proportion of subsequent injuries (0.75%, SIC-2.0 categories III
198 and IV) were injuries at the same site, of the same nature, and side, impacting a different structure, or
199 the same structure, not yet recovered. Reinjury after recovery, to the same site, of the same nature, side,
200 and structure represented 4.88% (SIC-2.0 category II) of subsequent injuries, with a decreasing
201 proportion of this type of subsequent injury nearing completion of the program.

202 3.5 Time to first and subsequent injuries within semesters

203 The median time to the first injury was seven weeks (95%CI:0.00-22.68) in the first and second
204 (95%CI:0.00-15.07) semesters of the program (Figure 2). The reported week of injury was not available

205 for one injury in semester one, and two injuries in semester six. Subsequently, these three injuries were
206 not included. The median time to the first injury was between nine to twelve weeks in each semester in
207 the second and third years of the program. The mean time to subsequent injury within all semesters
208 combined, decreased from 4.65 weeks between the first and second injury to 2.67 weeks between third
209 and fourth injuries.

210 3.6 Comparison between variables

211 There were significant differences using the Breslow test for median time to injury if injured in the
212 previous semester for the third ($p=0.04$), fourth ($p=0.01$), and fifth semesters ($p=0.001$). Those that were
213 injured in the previous semester had a median time to injury of: three weeks (95%CI: 0-6.24) in the
214 third semester; three weeks (95%CI: 1.99-4.01) in the fourth semester; and six weeks (95%CI: 0.61-
215 11.40) in the fifth semester. For those that were not injured in the previous semester, a median time to
216 injury was not reached for the third, fourth and fifth semesters. For those not injured in the previous
217 semester: two participants were injured in the third semester, with a reported injury onset in the eighth
218 and thirteenth weeks; three participants injured in the fourth semester in the ninth, fourteenth, and
219 sixteenth weeks; and one participant injured in the fifth semester in the eleventh week.

220 4.0 Discussion

221 This investigation aimed to analyse injury incidence, subsequent injuries, and time to the first injury
222 across participation in a three-year tertiary dance training program. To our knowledge, this is the first
223 paper to report on longitudinal injury data across an entire training program for a cohort that has
224 completed their dance training. It is also to our knowledge one of few studies^{5 12} to report on subsequent
225 injuries in pre-professional dance, and one of few studies^{9 26-31} to consider subsequent injuries using
226 SIC^{9 13}.

227 The medical attention injury incidence of 2.71 (95% CI:2.22, 3.20) per 1000 hours was lower than that
228 of Bronner et al.³² investigating pre-professional modern dancers, though higher than injury incidences
229 reported in other studies^{4 5} on pre-professional ballet and contemporary dance cohorts, also using a
230 medical attention injury definition. It is worth noting that the clinic available to students in this

231 investigation, is complimentary, available once per week, which may influence the presentation of
232 injuries. The training weeks (28 weeks) in this investigation appear to be less than other studies
233 mentioned above that could also influence injury incidence. Bronner et al.³² reported a 34-week training
234 year, and Kenny et al.⁴ reported 31- and 40-week training years. The prevalence of injury was 100%
235 for the three years of the training program. No significant differences were identified to consider RaR
236 and RiR for each semester relative to other semesters combined (Table 1.).

237 In a systematic review⁸, it was calculated that the first-year pre-professional ballet students in the study
238 by Ekegren et al.¹² had a significantly decreased rate of injury compared with the higher year levels.
239 The higher injury incidences in the final year students in the study by Ekegren et al.¹² was thought to
240 be related to an increase in rehearsal training hours, that could also be the case in this investigation.
241 Conversely, first-year pre-professional ballet and contemporary dance students in the study by Lee et
242 al.⁵ had a significantly increased rate of injury compared with the higher year levels. A trend is observed
243 in this investigation regarding an increased incidence of injury across the program (see Figure 1) in line
244 with the findings of Ekegren et al.¹², although not significant that could relate to the low participant
245 numbers investigated here.

246 It was revealed that the majority of subsequent injuries (74.86%) are at a different site and of a different
247 nature, which is comparative to 78.7% in rugby sevens squads⁹, 79.3% in water polo players²⁹, and 75%
248 in elite AFL players³⁰. These similarities are of interest, given the different sporting pursuits, and guides
249 the direction of tertiary injury reduction strategies to different sites to previous injury. A trend was seen
250 for a decreasing proportion of subsequent injuries occurring at the same site, of the same nature, side,
251 and structure after recovery nearing completion of the program. This might represent improved self-
252 management of injuries as students' progress through their training.

253 The median time to the first injury for each semester increased from seven weeks in each semester of
254 the first year to nine to twelve weeks in following year levels. This early time to first injury in the first
255 semester of the program is despite the scheduling of a training program for the first four weeks of the
256 first semester. The four-week training program involved an increase in physical training hours from
257 nine in the first week with no technique classes, to 22.5 hours with six technique classes. The fifth week,

258 which was the first week to commence regular training included 27 physical training hours, with 10
259 technique classes, 3 rehearsal sessions, and one session of yoga and pas de deux each. A change in the
260 intensities or durations of training, lack of graduated increases of dance specific skills, or participation
261 in conditioning activities different to usual dance training, could explain for the early time to the first
262 injury.

263 The mean time to subsequent injuries within a semester decreased with greater than three subsequent
264 injuries. This relates to a trend seen of increasing hours across the program and increasing proportion
265 of time committed to rehearsal in the third year, as identified by Ekegren et al.¹². The increasing number
266 of subsequent injuries as the program progresses could also relate to decreased acceptance to modify
267 training to allow for recovery. Results showed a significant difference for recording an injury if injured
268 in the previous semester for the third, fourth and fifth semesters of the program. This suggests that
269 recorded injuries in the second, third and fourth semesters have a significantly shorter time to injury in
270 the next semester.

271 A limitation of the current study is the low number of participants, and that no information is known
272 about students who did not complete the dance program, thus survivor bias should be considered which
273 may underestimate the results. The severity of injuries was unable to be ascertained, given no records
274 of time to recovery were available due to the nature of the physiotherapy clinic being for the initial
275 presentation only. Some injuries that occurred may not have been recorded due to several factors,
276 including: physiotherapy services were only available once per week; where students might not have
277 been available to present to the clinic at times available; and/or in the case of more severe injuries, they
278 could have presented to external practitioners. Only injuries related to dance training were included,
279 and, therefore, injuries sustained outside of dance training may have influenced the number of
280 subsequent injuries.

281 A medical attention injury definition was used, thus injuries that did not require medical attention were
282 not included. This may introduce measurement bias that may have led to an underestimation of injury
283 incidence, particularly the number of injuries, and nondifferential misclassification. Furthermore, it
284 cannot be confirmed if students commenced each semester injury-free. Hours were used as the measure

285 of exposure, from timetables, rather than attendance, and participants could have participated in further
286 dance training not captured in this data. This again could introduce measurement bias, and in this case
287 lead to an overestimation of injury incidence, with the denominator of hours of exposure possibly
288 underestimated. The majority of subsequent injuries were reported by a proportion of the participants,
289 thus the data could be skewed by these individuals.

290 The challenge of the training year divided into semesters in academia is recognised; therefore, it is
291 suggested that pre-professional training is considered as a three-year continuum³³. This study
292 demonstrates 50% of students are injured by week seven within each semester of the first year, and the
293 probability of sustaining an initial injury within the semester appears to plateau after this point, different
294 to other semesters (see Figure 2). Perhaps grading the intensity or duration of training in the earlier
295 stages of each semester of the first year of pre-professional training could lead to a decrease in injury.

296 Future research should use exposure measures beyond training hours and take into account the intensity
297 of training and volume of specific skills. Subsequent injury categorisation^{9 13} should be considered in
298 other dance contexts such as in professional dance to guide tertiary injury reduction strategies. Weekly
299 injury data should be utilised to further guide when to direct injury reduction strategies. Investigating
300 the implementation of injury reduction strategies requires exploring the beliefs of stakeholders³⁴.

301 **5.0 Conclusions**

302 This is the first study to retrospectively investigate all injuries recorded to complete a three-year tertiary
303 ballet and contemporary dance training program. The incidence of medical attention injury was 2.71
304 per 1000 hours, with a trend of increasing incidence across the program. Inferences are made into
305 possible factors relating to the trend of increasing incidence seen, namely increasing hours, and
306 increasing the proportion of hours devoted to rehearsal. The ankle was the most common injury location
307 and muscle the most common tissue injured. Most subsequent injuries were at a different site, and of a
308 different nature. Reinjury after recovery, to the same site, of the same nature, side, and structure
309 represented 4.88% of all subsequent injuries. The median time to the first injury was seven weeks in

310 the first and second semesters, in the first year of the program. Subsequent semesters had later median
311 times to the first injury.

312 Future research should consider narrower exposure measures than training hours, such as training
313 intensity and the repetition of skills. Subsequent injuries should be further considered in dance contexts,
314 and weekly injury data utilised to further consider when injuries occur to direct injury reduction
315 strategies. To guide the implementation of injury reduction interventions, stakeholder perceptions
316 should be explored.

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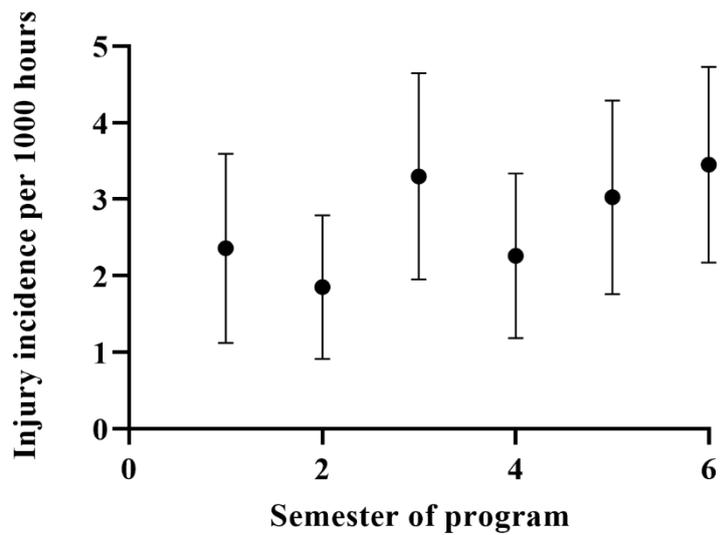
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410 **TABLE1.** Risk and rate ratios of injury for each semester

Year level	Semester of program	Participants	Participants injured	Risk ratio (95% CI) Nb. Semester relative to other semesters combined	Number of injuries	Hours of exposure	Rate ratio (95% CI) Nb. Semester relative to other semesters combined
1	1	17	10	0.94 (0.61, 1.45)	14	5933.75	0.85 (0.49, 1.49)
	2		11	1.06 (0.72, 1.56)	15	8096.25	0.64 (0.37, 1.10)
2	3		10	0.94 (0.61, 1.45)	23	6970.00	1.27 (0.81, 2.00)
	4		11	1.06 (0.72, 1.56)	17	7522.50	0.81 (0.48, 1.35)
3	5		11	1.06 (0.72, 1.56)	22	7269.00	1.14 (0.72, 1.82)
	6		10	0.94 (0.61, 1.45)	28	8111.50	1.36 (0.89, 2.07)

411 CI == confidence interval

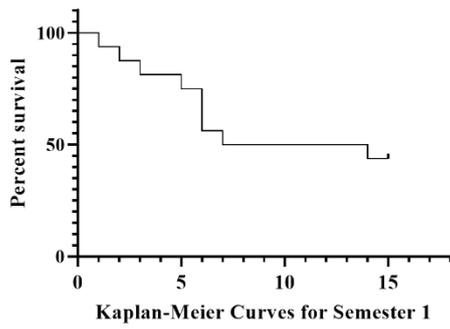
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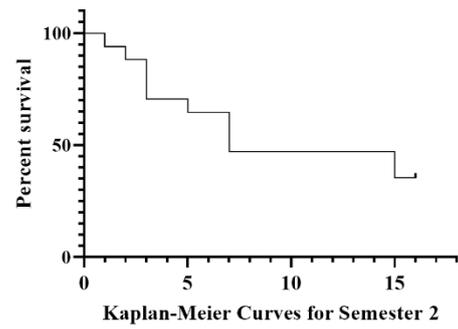
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414 **FIGURE 1.** The incidence of injuries per 1000 hours for each semester, with 95% confidence
415 intervals

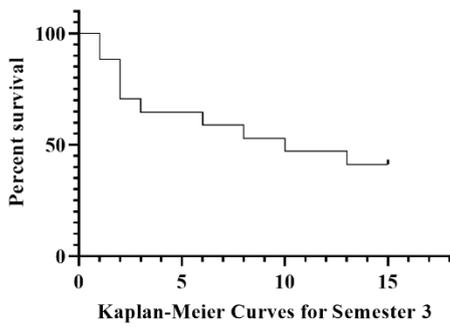
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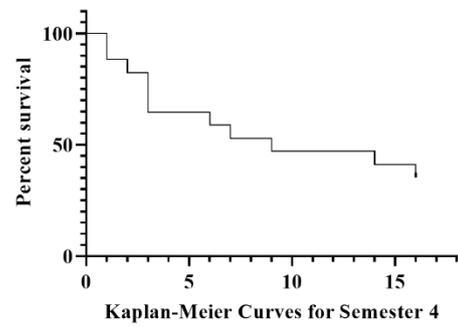
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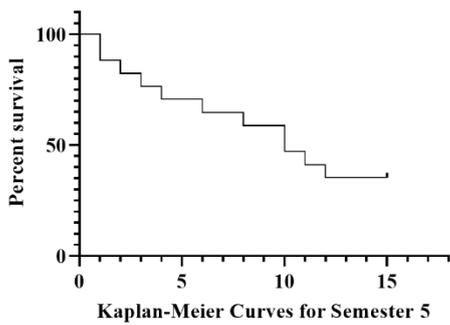
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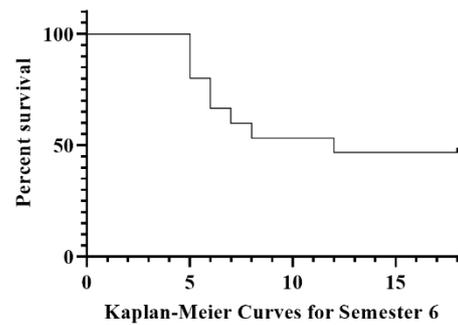
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418 **FIGURE 2.** The probability of remaining injury free for the reported week of injury onset for each
 419 semester of the program: a. semester 1, b. semester 2, c. semester 3, d. semester 4, e. semester 5, f.

420 semester 6

421