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Association of daily workload, wellness, injury and illness during tours in international cricketers

AUTHOR

Ahmun, Robert; McCaig, Steve; Tallent, Jamie; et al.

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1 **Association of Daily Workload, Wellness, Injury and Illness during Tours in International**
2 **Cricketers**

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5 ¹ **Robert Ahmun**, ^{1,2,7} Steve McCaig, ³ Jamie Tallent, ⁴ Sean Williams, ^{5,6} Tim Gabbett,

6

7 ¹ England and Wales Cricket Board, Leicestershire, UK

8 ² English Institute of Sport, Loughborough University, Loughborough,

9 ³ School of Sport Health and Applied Science, St Mary's University, Twickenham, UK

10 ⁴ Department for Health, University of Bath, Bath, UK

11 ⁵ Gabbett Performance Solutions, Brisbane, Australia

12 ⁶ Institute for Resilient Regions, University of Southern Queensland, Ipswich, Australia

13 ⁷ School of Sports Science, Cardiff Metropolitan University, Cardiff, UK

14

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19 **Address for Correspondence:**

20 National Cricket Performance Centre

21 Loughborough University

22 Leicestershire

23 UK

24 LE11 3TU

25 Tel: 01509 228664

26 Fax: 01509 453718

27 Email: rob.ahmun@ecb.co.uk

28

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30 **ABSTRACT**

31 **Purpose:** To examine the relationship between player internal workloads, daily wellness
32 monitoring, injury and illness in a group of elite adolescent cricketers during overseas
33 competitions. **Methods:** Thirty-nine male international adolescent cricketers (17.5 ± 0.8 yr)
34 took part in the study. Data was collected over five tours across a three-year period (2014-
35 2016). Measures of wellness were recorded, and daily training loads calculated using
36 session-rating of perceived exertion. The injury and illness status of each member of the
37 squad was recorded daily. Acute and chronic workloads were calculated using three days
38 and fourteen days moving averages. Acute workloads, chronic workloads, and acute chronic
39 workload ratios (ACWR) were independently modelled as fixed effects predictor variables.
40 **Results:** In the subsequent week, a high 3-day workload was significantly associated with an
41 increased risk of injury (Relative Risk [RR] = 2.51; CI = 1.70 to 3.70). Similarly, a high 14-day
42 workload was also associated with an increased risk of injury (RR = 1.48; CI = 1.01 to 2.70).
43 Individual differences in the load injury relationship were also found. No clear relationship
44 between the ACWR and injury risk was found, but high chronic workloads combined with a
45 high or low ACWR showed an increase probability of injury compared to moderate chronic
46 workloads. There were also trends for sleep quality and cold symptoms worsening the week
47 before an injury occurred. **Conclusion:** Although there is significant individual variation,
48 short term high workloads and changing in wellness status appear to be associated with
49 injury risk.

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52 **Key Words:** Cricket, Workloads, Injury, Wellness

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63 **INTRODUCTION**

64 It is well established that injury rates can influence the success of a team ¹ and consequently
65 managing loads appear to be an essential part of reducing injury risk. Training loads
66 comprise of both internal and external loads. External load relates to the amount of work
67 completed, whilst internal loads are a measure of the relative physiological strain. This
68 relationship is crucial in determining the stress and adaptive response ². Furthermore, the
69 rate of loading is a critical factor in influencing performance and injury factor ³. If loads are
70 applied in a moderate and progressive manner, they may be protective against injury ². No
71 single marker can be used to accurately predict when an athlete enters a maladaptive state,
72 so a combination of both internal and external load measures, specific to the nature of the
73 sport, is recommended ^{3,4}.

74

75 Despite the increased use of global positioning system (GPS) to record load in the literature
76 ⁵, external load of cricket fast bowling is predominantly measured using the number of balls
77 bowled ^{6,7}. However, recently balls bowled has been shown to inadequately capture the cost
78 of fast bowling ⁸. Consequently a hybrid of the session-rating of perceived exertion (sRPE) ⁹,
79 TRIMP and balls bowled has been used to model injury risk in cricket. Hulin, Gabbett,
80 Blanch, Chapman, Bailey, Orchard ¹⁰ was the first to investigate this specifically in cricket
81 and combined both external (balls bowled) and internal load data (sRPE x duration) to
82 model injury risk in fast bowlers. Despite a significant relationship between acute (1-week)
83 external workloads and increased injury risk in the current week, no relationships were
84 demonstrated between sRPE's and injury risk in the current or subsequent week. However,
85 when both the external and internal acute workload exceeded chronic (4-week rolling
86 average) workload, resulting in an acute chronic workload ratio (ACWR) of >2.0, the relative
87 risk of fast bowling injury was 3.3 to 4.5 times greater. As balls bowled does not appear to
88 accurately reflect external workload ⁸, internal workloads may be more strongly associated
89 with injury as it encompasses all aspects of training and competition.

90

91 It is also highlighted that progressively higher workloads may serve as a protective
92 mechanism against injury ¹⁰. Unfortunately, progressive sequenced training to develop high
93 chronic training loads is not always feasible, particularly in adolescent cricket where

94 overseas tours occur out of season. The nature of touring results in intensive training
95 periods followed by a congested fixture period. These, intensive training periods have led to
96 an increase catabolic environment during the competition period ¹¹. Whilst an increased
97 catabolic environment does not necessarily directly influence performance, it can indicate
98 the ability of the athletes to tolerate training load ¹². Short duration tours have resulted in
99 an increased injury risk in many other sports ^{13,14} although it is unclear if cricket has similar
100 traits. Even though a significant amount of a cricketer's career is spent touring various
101 countries, the effect this has on injury risk is unknown. As less recovery between days of
102 bowling has been shown to increase the risk of injury in young (14.7 ± 1.4 years) fast
103 bowlers ⁶, it is hypothesised that touring would also be associated with a high risk of injury.
104 A recent systematic review has highlighted the large quantity of self-reported measures of
105 wellness that are used in sport ¹⁵. However, despite this review the relationship with injury
106 and well-being is inconclusive. Therefore, the aim of this study was to examine the
107 relationship between internal workloads, daily wellness scores, injury and illness in a group
108 of elite adolescent cricketers during overseas competitions.

109

110 METHODS

111 Participants

112 The sample comprised 39 male adolescent cricketers (17.5 ± 0.8 y) who were selected to
113 play international age group cricket. Data were collected over five tours across a three-year
114 period (2014-2016). Tour duration varied from 18 to 30 days with a mean tour duration of
115 24 ± 5 days. Of the five tours, 26% of the participants ($n = 10$) played one tour, 53% ($n = 20$)
116 played two tours and 21% ($n = 8$) played three tours – equating to 1862 training days. Data
117 were collected as a part of the routine practices throughout the tour season to which all
118 players had consented ¹⁶. The project was approved by St Mary's University Ethics
119 Committee in the spirit of the Helsinki Declaration.

120

121 Wellness Data

122 Subjective measures of wellness were recorded each morning at breakfast using a five-point
123 scale for sleep quality and duration, muscle soreness, cold symptoms and mood with lower
124 scores being indicative of reduced wellness ¹⁷.

125

126 Internal Workload

127 Players were asked to provide a subjective rating of perceived exertion (RPE) using a 10-
128 point rating scale ⁹. The intensity of all sessions (games, cricket training and strength and
129 conditioning) were recorded within 30 mins of completing the session. Daily training loads
130 were then calculated by multiplying session RPE by session duration (min).

131

132 Injury Data Collection

133 The programme's physiotherapist collected the data throughout the course of the study and
134 the same practitioner was the programme physiotherapist for the duration of the study. A
135 programme day was defined as any day where the squad was together, be it for a match,
136 training, rest or travel day. For each programme day the squad physiotherapist recorded the
137 injury status of each member of the squad on a specifically designed spreadsheet. A broader
138 definition of injury and illness, as used in the current study, provides a more complete
139 picture of the true burden of injury and illness than a time loss definition of injury and
140 illness. The recent international injury consensus statement on injury surveillance¹⁸ in
141 cricket updated its definition of a cricket injury to include medical attention conditions and
142 our paper is consistent with this consensus statement. Each player's injury status was
143 recorded as being either:

144 1. Fully available for training and matches, with no injury or illness

145 2. Fully available for training and matches, but with an injury or illness

146 3. Available for selection in a major match, but with modified activity due to injury or
147 illness

148 4. Unavailable for selection in a major match due to injury or illness

149 Non time-loss injuries were category 2 and 3 and time-loss injuries were category 4. All new
150 injuries, as well as any pre-existing injuries players carried into the programme were
151 reported. It was possible for a player to have multiple injuries or illness at any one time e.g.

152 they may have a medical condition while being treated for a musculoskeletal condition or
153 they may have two or more musculoskeletal conditions requiring management at the same
154 time.

155 A change in injury status occurred when a player's injury status changed from one to
156 another e.g. a player sustained a hamstring strain and was unavailable for selection
157 (category 4), but the previous day they were fully available with no injury or illness (category
158 1). Only injury status changes where the players' condition worsened i.e. they required
159 increasing medical attention or activity/participation restriction; were included for analysis.
160 This was a negative injury status change. This occurred when their injury status category
161 number increased and was considered a negative status change.

162 For each injury or illness, the squad physiotherapist also recorded the players skill group,
163 the side, region and location of injury, diagnosis based on the Orchard sports injury
164 classification system 10 (OSICS10) ¹⁹ and the number of programme days spent in each
165 injury status category. In addition, the mode of injury onset, activity at the time of onset and
166 whether it occurred on a match or non-match day was recorded as well. Skill group was
167 defined as per the international consensus statement guidelines ¹⁸, with players classed as
168 either batsman, pace bowlers, slow bowlers or wicketkeepers. The mode of onset followed
169 the consensus statement guidelines (Orchard, Ranson, Olivier et al, 2016), and was defined
170 as either sudden onset, impact (blow or contact), gradual onset, insidious or illness. Sudden
171 onset injuries comprised non-impact muscle strains and ligament sprains e.g. an ulnar
172 collateral ligament sprain during a one-off throw. Impact injuries occurred because of
173 contact with another player or object e.g. a contusion due to being hit by the ball. A gradual
174 onset injury was where the condition developed over time e.g. a rotator cuff tendinopathy
175 from repetitive throwing. An insidious onset was where there was no identifiable activity
176 associated with a musculo-skeletal injury. Illness was any medical condition not associated
177 with the other four mechanisms.

178

179

180

181 Data Analysis

182 'Programme' exposure was calculated by multiplying the number of players in each squad
183 during each day of the programme by the number of programme days, using the following
184 formula:

$$185 \quad \textit{Programme player days} = (\textit{daily squad size} \times \textit{number of days on programme})$$

186

187 Statistical Analysis

188 All estimations were made using the lme4 package with R (version 3.3.1, R Foundation for
189 Statistical Computing, Vienna, Austria). Acute and chronic workloads were calculated using
190 exponentially-weighted moving averages with time constants of three days and fourteen
191 days, respectively ²⁰. These time frames were chosen to reflect the 'tour' format of the
192 competitions analyzed (i.e., 18 to 30 day tours with limited chronic loading) and because
193 exponentially-weighted moving averages have shown stronger relationships with injury risk
194 than the usual one and four week rolling periods ²¹. Uncoupled ACWR were calculated by
195 reporting acute workloads (i.e., fatigue) as a proportion of chronic workloads (i.e., fitness)
196 ¹⁰, such that acute load periods were not included in the calculation of chronic load ²².
197 Within-individual Z-scores were calculated for each player using the following formula:

198 $(\textit{individual player's score} - \textit{individual player's average}) / \textit{individual player's standard}$
199 $\textit{deviation}$; a Z-score is the number of standard deviations the response is above or below
200 the mean of the distribution.

201 A generalized linear mixed-effects model (GLMM) was used to model the association
202 between workloads and injury risk in the subsequent week. This mixed effects model was
203 selected for its ability to account for repeated measurements, and to explore individual
204 responses between workloads and injury risk. Acute workloads, chronic workloads, and
205 ACWR were independently modelled as fixed effects predictor variables. In addition, the

206 interaction between ACWR and both acute and chronic workloads was assessed by including
207 multiplicative terms in the model. Random effects were athlete identity (differences
208 between athletes' mean injury risk), athlete \times tour (variability within athletes between
209 tours), and the residual. If assessment of a quadratic trend between the workload measure
210 and injury risk was significant ($P \leq 0.05$), the measure was split into tertiles for analysis, with
211 the lowest load range being the reference group. Otherwise, linear effects for continuous
212 predictor variables were evaluated as the change in relative injury risk (RR) associated with a
213 two standard deviation increase in the workload or wellness measure (representing the
214 change associated with a 'typically low' versus a 'typically high' value of the predictor) ²³.
215 The odds ratios obtained from the GLMM model were therefore converted to RR in order to
216 interpret their magnitude ²⁴. The RR represents the change in injury risk associated with
217 changes in the investigated load or wellness variables. A RR of 1.0 represents no change in
218 risk of injury, whilst values of 0.5 and 2.0 would represent a halving or doubling of injury
219 risk, respectively.

220 Magnitude-based inferences were used to provide an interpretation of the real-world
221 relevance of the outcomes ²⁵. The smallest important increase in injury risk was a RR of 1.11,
222 and the smallest important decrease in risk was 0.90 ²⁵. An effect was deemed unclear if the
223 chance that the true value was beneficial was $>25\%$, with odds of benefit relative to odds of
224 harm (odds ratio) of <66 . Otherwise, the effect was deemed clear, and was qualified with a
225 probabilistic term using the following scale: $<0.5\%$, most unlikely; 0.5-5%, very unlikely; 5-
226 25%, unlikely; 25-75%, possible; 75-95%, likely; 95-99.5%, very likely; $>99.5\%$, most likely ²⁶.
227 The *r2glmm* package was used to determine whether model fit was significantly improved
228 when using GLMM in comparison with a logistic regression model (which does not account
229 for repeated measurements or individual variations in responses).

230 RESULTS

231 Thirty-nine players were involved in 1862 programme days during the study. There were 98
232 injuries in 38 players that resulted in 130 negative injury status changes on 125 different
233 programme days. Only 17 (13.1%) of these changes resulted in the player being unavailable
234 for match selection (category 4). On average players had a negative injury status change
235 every 14.3 days. In most negative status changes (53.1%) players went from being fully

236 available to receiving medical attention (change status from category 1 to 2), the next most
237 common status changes were from fully available to modified activity (category 1 to 3) with
238 20% of all changes; and from medical attention to modified activity (category 2 to 3) with
239 13.8% of all changes. Sixteen pace bowlers accounted for 43.7% of all programme days and
240 46.9% of all negative status changes, nine spin bowlers accounted for 24.9% of programme
241 days and 26.9% of all changes, nine batsmen accounted for 19.8% of programme days and
242 15.4% of all changes and five wicketkeepers accounted for 11.6% of programme days and
243 10.8% of all changes. Compared to pace bowlers (RR = 1.00 (ref)), wicket keepers and
244 batsmen had a lower overall risk of injury (RR = 0.56; CI = 0.29 to 1.08), whilst the inference
245 for spin bowlers was unclear (RR: 0.70, CI = 0.31 to 1.57).

246

247 ****Insert Table 1 here****

248

249 Wellness and Injury Risk

250 No relationship was found between wellness scores and injury risk in the subsequent week,
251 although there were trends for sleep quality and cold symptoms to worsen the week before
252 an injury occurred (Table 1).

253

254 ****Insert Table 2 here****

255

256 Acute and Chronic Workloads

257 In the subsequent week, a high (>0.35) 3-day workload z-score was significantly associated
258 with an increased risk of injury (RR = 2.51; CI = 1.70 to 3.70; likelihood range >99.5%, most
259 likely), compared with medium (-0.45 to 0.35) and low (<-0.45) workload z-scores (Table 2).
260 The predicted probability of injury increased from 6% to 11% as 3-day workload increased
261 from medium to high categories. This is in comparison to overall risk of pace bowlers (RR =
262 1.00 (ref)), wicket keepers and batsmen (RR = 0.56; CI = 0.29 to 1.08), spin bowlers (RR:
263 0.70, CI = 0.31 to 1.57).

264

265 ****Insert Table 3 here****

266

267 A high (>0.67) 14-day workload z-score was also associated with an increased risk of injury
268 (RR = 1.48; CI = 1.01 to 2.70; likelihood range 75-95%, likely), compared with medium (-0.45
269 to 0.35) and low (<-0.45) workload z-scores (Table 3). The predicted probability of injury
270 increased from 8% to 13% as 14-day workload increased from medium to high categories.

271

272 ****Insert Table 4 here****

273

274 The ACWR was not clearly associated with injury risk (Table 4). Both acute and chronic
275 workloads were independently associated with injury risk in a linear fashion (Figure 1), with
276 2 standard deviation increases in both predictors (620 AU and 538 AU, respectively)
277 associated with substantial increases in injury risk (Acute: RR: 1.82, CI = 1.34 – 2.47, most
278 likely harmful; Chronic: RR: 2.22, CI: 1.56 – 3.15, most likely harmful).

279

280 ****Insert Figure 1 here****

281

282

283 Additionally, there was a clear interaction effect between ACWR categories and chronic
284 workloads (Figure 2), such that the effect of increasing chronic workloads on injury risk was
285 substantially higher in the 'low' and 'high' ACWR categories, compared to the 'moderate'
286 ACWR category. There was no interaction effect observed between ACWR and acute
287 workloads (P = 0.30).

288 ****Insert Figure 2 here****

289

290 There was a substantial improvement in model fit when random effects were included in
291 the model (logistic regression model $R^2 = 10\%$, GLMM model $R^2 = 27\%$, $P < 0.001$). Therefore,
292 individual differences in workload-injury relationships were evident. Figure 3 displays the
293 relationship between chronic workloads and injury risk in the subsequent week for each
294 individual in the analysis, as estimated via the GLMM.

295

296 ****Insert Figure 3 here****

297

298

299 DISCUSSION

300 This is the first study to establish specific workload thresholds for adolescent cricketers and
301 also non-fast bowlers. The study had numerous key findings. Firstly, high short-term (3 days)
302 workloads (>2125 AU) or a high 14 day workload (>7212 AU) were also associated with an
303 increased injury risk. Secondly, high chronic loads combined with a high or low ACWR
304 increases the probability of injury compared to moderate chronic loads. Thirdly, individual
305 differences in injury risk was also demonstrated between players. Finally, sleep quality and
306 cold symptoms showed a trend with injury risk.

307

308 The findings from our study show that high short-term workloads in cricket (>2125 AU)
309 increase the risk of injury. High workloads and increased injury risk may be a result of in-
310 adequate recovery time between sessions. Particularly during the early days of touring, an
311 optimal balance between intensity and volume of training and recovery needs to be
312 implemented. These findings are in-line with previous sports such as rugby²⁷ and football²⁸.
313 In contrast to our findings, previous work in cricket¹⁰ has found no link between acute
314 internal workload measures and injury risk. One explanation for the difference could be the
315 age and experience of the players involved in the study. Hulin, Gabbett, Blanch, Chapman,
316 Bailey, Orchard¹⁰ used older (26 ± 5 yr), more experienced cricketers who have had
317 exposure to higher chronic workloads compared to the younger (17.5 ± 0.8 years)
318 adolescent cricketers in our study. Individuals with a greater physical training history or
319 greater physical attributes have also shown better tolerance to acute spikes in load better
320 than younger individuals²⁹. Therefore, the finding of greater injury risk with rapid acute
321 changes in load in adolescent cricketers may be expected. Conversely, older athletes appear
322 to be at greater risk of injuries at a given absolute training load than younger athletes³⁰.
323 Whilst this appears to be a contradictory finding, there may be a 'sweet spot' for age,
324 physical qualities and training history where athletes can cope with acute spikes in training
325 loads. Other differences between the findings in this study may due to the classification or
326 change in injury states we used compared to time loss data¹⁰. Our study also used a change
327 in injury status that is more reflective of current sporting practices.

328

329 The non-significant relationship between the ACWR and risk of injury or illness is in contrast
330 to previous work in senior cricket fast bowlers¹⁰ and elite adolescent cricketers³¹. Our

331 findings uniquely show that high chronic loads combined with a high or low ACWR increases
332 the probability of injury compared to moderate chronic loads. Previously, higher chronic
333 workloads have shown to serve as an injury protective mechanism for acute spikes in
334 workload ³². Conversely, high chronic loads can be achieved safely so long as the ACWR is
335 not excessive. Despite being beyond the scope of this study, it seems essential that the
336 workload prior to touring is recorded. If players have accumulated large workloads before
337 touring then ensuring ACWR is not minimised or excessive would appear to reduce the risk
338 of injury.

339

340 Individual differences in injury risk were also demonstrated between playing positions for
341 the first time showing that athletes should understand individual responses to chronic
342 workloads. Prescribing individual load is often very difficult in a team setting, but our data
343 suggests that ensuring all players are below (>2125 AU) will reduce the risk of injury. The
344 length of the acute window has also been shown to be strongly associated with injury ³³.
345 Given that players do not have the opportunity to build chronic workloads prior to touring,
346 our study used time frames of 3 and 14 days for acute and chronic loading periods. Work
347 has predominantly used time frames of 7 and 28 days though there is evidence to suggest
348 that 6 and 21 days acute to chronic workload ratios is optimal for predicting injuries ³³.
349 Consequently, it could be suggested that the 3 days used for the acute period in our study
350 was not long enough to see differences in ACWR.

351

352 A positive link between alterations in training load and subjective measures of well-being
353 has previously been established ^{34,35}. A recent systematic review ¹⁵ has highlighted that
354 subjective well-being measures respond consistently to stress imposed by training. Of 56
355 research articles, 85% favoured subjective measures when monitoring athlete load.
356 Negative changes in wellness measures have also been linked to increased risk of illness ³⁶,
357 although changes in wellness measures and risk of injury has received less attention ³⁷. The
358 result from our study showed no significant relationship between subjective measures and
359 injury and illness. A possible explanation for these findings may be the due to the scale
360 used. Our study used a 5-point scale where previous work has shown that a greater number
361 of points on a scale increases the sensitivity ³⁸. However, we did observe trends of reduced
362 sleep and self-reported cold symptoms in the week before an injury occurred. Recent work

363 by von Rosen, Frohm, Kottorp, Friden, Heijne ³⁷ supports this notion and demonstrated that
364 in youth athletes, an increase in training load and intensity in addition to a decrease in sleep
365 volume significantly increased the risk of injury. With even modest sleep loss associated
366 with impairment of psychomotor performance ³⁹ it appears logical that assessing sleep
367 volume and quality is a key subjective measure for reducing injury and illness risk.

368

369 LIMITATIONS

370 Although higher chronic workloads have been shown to be associated with a lower risk of
371 injury, it was not possible to quantify chronic training workloads in the period prior to tours.
372 Therefore, future work should focus on the workloads preceding a tour and the effects this
373 has on injury prevalence. Subjective measures of wellness were asked during breakfast.
374 Whilst the experimenters made every attempt to ensure this was performed away from
375 other coaches and players, the nature of the touring environment sometimes meant
376 wellness measures were not performed in isolation. Finally, the nature of cricket often
377 involves large periods of very low inactivity such as fielding in a match. This low RPE but long
378 duration can often cause excessively large TRMP values.

379

380 CONCLUSION

381 Collectively, these results demonstrate that in elite adolescent cricketers, high acute and/or
382 chronic internal workloads are significantly associated with an increased risk of injury. Rapid
383 increases in acute workloads >2125 AU are more closely associated with injury and illness
384 than ACWR assessed over 3 and 14 days respectively. High chronic loads combined with a
385 high or low ACWR increases the probability of injury compared to moderate chronic loads.
386 Therefore, practitioners should ensure individuals that accumulate large amounts of
387 workload have a moderate ACWR whilst touring. However, the injury risk appears to be an
388 individualised response. We have demonstrated for the first time that other cricket skill sets
389 (in addition to fast bowling) have injury risks associated with workloads. Although not
390 significant, measures of wellness, specifically sleep duration and self-reported cold
391 symptoms can be expected to worsen the week before an injury occurs.

392

393 PRACTICAL IMPLICATIONS:

394

- 395 • The non-invasive and simple session-RPE method is useful for tracking training and
396 game loads and injury risk during elite adolescent cricket tours.
- 397 • Coaches should avoid spike in workloads when chronic workloads are high or low.
- 398 • Players appear to be at an increased risk of injury when they experience a high 3 day
399 cumulative load (≥ 2125 AU), though there are individual differences.
- 400 • Although not significant, worsening sleep quality and self-reported cold symptoms
401 are possible subjective indicators of heightened injury risk in this population. These
402 measures warrant further investigation in larger studies in the future.

403

404

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Wellness	Relative risk	Lower CL	Upper CL	Inference	P-value
Total wellness	0.96	0.82	1.13	Unclear	0.70
Sleep duration	0.98	0.83	1.16	Unclear	0.87
Sleep quality	0.89	0.76	1.05	Possibly ↓	0.25
Body feeling	0.91	0.77	1.08	Possibly trivial	0.35
Cold symptoms	0.86	0.72	1.02	Possibly ↓	0.15
Mood	1.00	0.84	1.18	Unclear	0.98

544 **Table 1.** Change in injury risk associated with a 2SD improvement in self-reported wellness
545 indicator.

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574 **Table 2.** Acute and chronic workloads express as AU and z-scores

	Z-Score	sRPE AU's
Acute Workload (3 Days)		
Low	<-0.45	523 - 1322
Medium	-0.45 to 0.35	1323 - 2124
High	>0.35	>2125
Chronic Workload (14 Days)		
Low	<-0.40	2051 - 5128
Medium	-0.4 to 0.67	5129 - 7211
High	>0.67	>7212

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Table 3. Predicated probability of injury expressed relative to z-scores.

	Relative risk	Lower CL	Upper CL	Inference	P-value
3-day load z-score					
Low (<-0.45)	1.00 (ref)				
Medium (-0.45 to 0.35)	1.18	0.73	1.93	Unclear	0.56
High (>0.35)	2.40	1.57	3.66	Most likely ↑	0.0007
14-day load z-score					
Low (<-0.40)	1.00 (ref)				
Medium (-0.40 to 0.67)	1.18	0.82	1.71	Unclear	0.46
High (>0.67)	1.89	1.26	2.85	Most likely ↑	0.01

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618 **Table 4.** Predicted probability of injury risk.

Acute:chronic workload	Relative risk	Lower CL	Upper CL	Inference	P-value
Low (<0.80)	1.00 (ref)	-	-	-	-
Medium (0.80 to 1.30)	0.99	0.64	1.56	Unclear	0.99
High (>1.30)	1.01	0.65	1.58	Unclear	0.96

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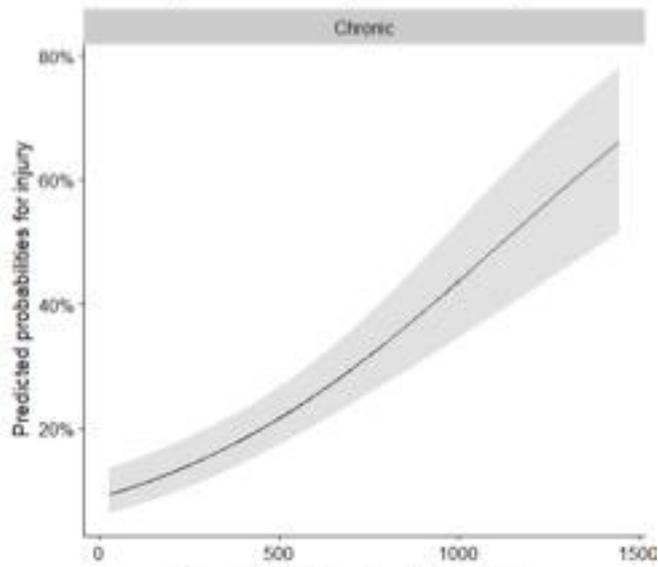
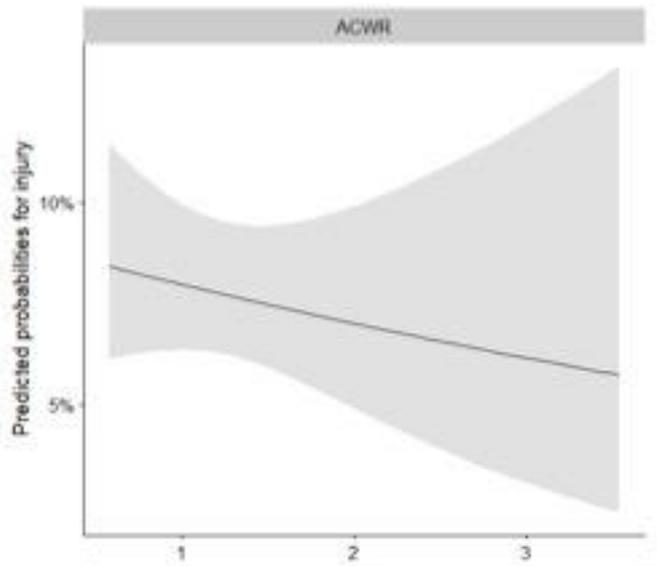
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Figure Legends

Figure 1. Acute, chronic and acute chronic workload ratio probability of injury.

Figure 2. Acute, chronic and acute to chronic workload ratios association with injury risk.

Figure 3. Relationship between chronic workloads and injury risk in the subsequent week for each individual. Primary role is defined. BAT = Batsmant; PB = Pace Bowler; SP = Seam Bowler; WK = Wicket Keeper



Marginal effects of model predictors

