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The longest journeys in Super Rugby: 11 years of travel and performance indicators

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1 **The longest journeys in Super Rugby: 11 years of travel and**
2 **performance indicators**

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11 **The longest journeys in Super Rugby: 11 years of travel and** 12 **performance indicators**

13 Regular air travel is common in sport. The aim of this study was to understand the
14 extent to which travel has affected Super Rugby teams' performance from 2006,
15 the first season with available Key Performance Indicators (KPIs), to 2016. Data
16 were analysed with mixed linear models for the effects of number of time-zones
17 crossed (east or west), travel duration, the away-match disadvantage, difference in
18 ranking, a set of amendments to the laws of Rugby Union in 2008, a change in
19 competition format (introduction of a conference system) in 2011, and a secular
20 trend. In 2006 the predicted combined effects of travelling 24 hours across 12 time-
21 zones and playing away were trivial or small and negative but generally unclear
22 for most of the KPIs in both directions of travel. In 2016 more effects were clear,
23 small and negative for westward travel, while most effects for eastward travel were
24 clear, small to moderate and negative. Most KPIs showed small to moderate
25 increases over the 11 years, while difference in ranking, the introduction of new
26 rules and game format led to mostly small changes. Changes in the physical
27 demands of the game, and inadequate recovery time for long-haul travel can
28 explain these effects.

29 Word Count: 200/200

30 Keywords: Travel, jet lag, match analysis, performance analysis, away-match
31 disadvantage

32 **Introduction:**

33 Maximising performance and succeeding in competition are the final goals of every
34 professional athlete and coach. Measuring performance and its variations during a season
35 is crucial to increase the chance of winning a competition. Notational analysis is based
36 on the identification of Key Performance Indicators (KPIs) and it is the most common
37 form of performance assessment in team sports (Hughes & Bartlett, 2002) as it is
38 relatively inexpensive and the results are easily understood by both coaches and athletes
39 (Barris & Button, 2008). However, performance in team sport is a complex process and

40 several constraints can influence athletes' outcomes (Glazier, 2010). Frequent air travel
41 is one of these constraints (Leatherwood & Dragoo, 2013) and is particularly common in
42 Super Rugby, which is arguably the most important Rugby Union competition for the
43 southern hemisphere. The competition is currently contested by 15 teams from five
44 countries (four from South Africa, five from New Zealand, four from Australia, and one
45 respectively from Argentina and Japan) and therefore travel is a key factor (SuperRugby,
46 2014a). Travel in Super Rugby ranges from a one hour flight with no time-zone change
47 to a 24 hour flight crossing 12 time-zones. As such, Super Rugby teams are an ideal
48 sample to analyse the effects of travel fatigue and jet lag on performance.

49 Travel fatigue is a state of persistent weariness, recurrent illness, and lack of
50 motivation that arises after every travel and tends to accumulate over time (Samuels,
51 2012). Jet lag occurs when the circadian rhythms, the rhythmic pattern of all the
52 physiological functions and systems of the human body (Czeisler et al., 1999), are not
53 synchronised with the external clock, typically after rapid travel across time-zones
54 (Waterhouse, Reilly, & Edwards, 2004). The number of time-zones crossed and direction
55 of travel dictate the duration and severity of jet lag symptoms, which include sleep
56 disturbances, fatigue, changes in mood and a deficit in cognitive skills (Herxheimer &
57 Petrie, 2002; Revell & Eastman, 2005). The effect of travel fatigue and jet lag on athletes'
58 performance has been investigated before but mostly for athletes competing in individual
59 sports (Bullock, Martin, Ross, Rosemond, & Marino, 2007; Lemmer, Kern, Nold, &
60 Lohrer, 2002), using non-specific markers of performance, i.e. grip strength, or general
61 physical tests (Fowler, Duffield, & Vaile, 2015; Reilly, Atkinson, & Waterhouse, 1997),
62 or monitoring athletes travelling locally or crossing only a small number of time-zones
63 (McGuckin, Sinclair, Sealey, & Bowman, 2014; Richmond et al., 2007).

64 The purpose of this study was to determine the effect of multiple time-zones
65 (long-haul) travel on team KPIs in the Super Rugby competition over an 11 year period
66 starting from the first season with available KPI data (2006). Other factors that could
67 affect KPIs were included in the analysis to estimate and adjust for these effects and
68 thereby potentially improve the precision of the estimate of the travel effects. These
69 factors were the match venue (home and away), the difference in ranking, match locations
70 and changes in rules and competition format.

71 **Material and methods:**

72 Archival data from 11 years of Super Rugby (2006-2016) were retrieved from the official
73 SANZAAR (South Africa, New Zealand, Australia, Argentina Rugby) web-site,
74 (<http://www.sanzarrugby.com/superrugby>). SANZAAR operates all international Rugby
75 Union competitions in the Southern hemisphere. The analysis was conducted according
76 to the ethical guidelines of the authors' institution. All data were from a public domain
77 so did not require ethical approval. All data were de-identified prior to inclusion. The
78 number of time-zones crossed and flight duration were calculated based on the location
79 of the city where a match was played and the location of the city where the previous
80 match was played. The time shift after crossing time-zones was adjusted for daylight-
81 saving time when required. Travel time was calculated considering the shortest possible
82 itinerary. Difference in ranking was calculated as the difference in the log of the ladder
83 position at the end of each season (Phillips & Hopkins, 2017); base-2 logarithms were
84 chosen for ease of interpretation (1 unit equal the doubling of the rank). In total, 2,474
85 observations from 1,237 Super Rugby matches were used, covering all iterations of the
86 competition from 2006.

87 For the New Zealand teams, matches that were not played at their home ground
88 but in a nearby location in their union territory were also considered home-matches. When
89 a match was played in a neutral ground (one match in England in 2011 and one in Fiji in
90 2016) they were considered away for both teams. The matches played in Singapore by
91 the Japanese team in 2016 were considered home-matches for home ground advantage
92 calculation. However, the distance covered whilst travelling by the Japanese team was
93 included in the analysis. In 2011, a New Zealand team was unable to play at their home-
94 ground due to an earthquake. In the analysis, unless played in their union territory, all
95 matches played by this team were considered away-matches, due to travel.

96 All available KPIs were retrieved from the web site. KPIs related to infrequent
97 events (e.g., drop goals), and KPIs available for less than eight years (e.g., mauls) were
98 not included in the analysis. The selected KPIs were organised in two groups: those for
99 which an increase would presumably represent an enhancement of team performance
100 (positive KPIs) and those presumably representing an impairment (negative KPIs). The
101 positive KPIs were counts per match for carries, clean breaks, conversions defenders
102 beaten, kicks in play (available from 2009 onward), offloads, passes, tackles, tries, rucks
103 won (%), scrums won (%), lineouts won (%), (available from 2009 onward), and metres
104 (m) run with the ball. The negative KPIs were counts of missed tackles, penalties
105 conceded and turnover conceded.

106 ***Statistical analysis:***

107 Data were imported into the Statistical Analysis System (version 9.4, SAS Institute, Cary,
108 NC). The effects on KPIs were estimated with generalised linear mixed models (Proc
109 Glimmix). For counts the model was over-dispersed Poisson regression and for
110 proportion the model was over-dispersed logistic regression. Linear numeric fixed effects
111 were included for the number of time-zones crossed in each direction of travel (east,

112 west), for flight duration, difference in ranking and for a secular trend. Dummy variables
113 were included for the away-match disadvantage (0 = home, 1 = away), for a set of
114 amendments to the laws of Rugby Union (InternationalRugbyBoard, 2008) implemented
115 in Super Rugby in 2008 (0 = pre2008, 1 = post2007), and for a change in competition
116 format with the introduction of a conference system (SuperRugby, 2014b) that occurred
117 in 2011 (0 = pre2011, 1 = post2010). To estimate and adjust for differences between teams
118 and for changes within teams between years and following eastward and westward travel,
119 team identity and its interaction with year of competition and eastward and westward
120 travel as nominal variables were included as random effects. The analyses were also
121 repeated with additional random effects to account for individual team differences in the
122 effects of eastward and westward travel; the random effects consisted of team identity
123 and its interactions with the linear numeric fixed effects for eastward and westward travel
124 across time-zones, allowing for correlations between these effects (specified with an
125 unstructured covariance matrix). Finally, to account for annual deviations from the
126 secular trend, year of competition was also included as random effect. Simpler analyses,
127 excluding all year effects, were performed for each year to justify inclusion of linear
128 trends for the fixed effects in the full model.

129 The effects of crossing time-zones and travel were predicted for the maximum
130 values in the Super Rugby competitions: 12 time-zones and 24 hours respectively
131 (Auckland to Cape Town). These effects were combined with the away disadvantage to
132 get the observed effect on team KPIs when competing at a remote venue. Each of these
133 effects was also assessed separately for its pure contribution to team KPIs. The combined
134 effect of travel and number of time-zones crossed, excluding the away-match
135 disadvantage, was assessed to determine the real importance of long-haul travel. The
136 secular trend was evaluated for the 11 years of competition analysed.

137 Effects were reported in percent unit with 90% confidence limits (Hopkins,
138 Marshall, Batterham, & Hanin, 2009). Magnitude of the effects were assessed using
139 standardisation, with threshold values for small, moderate, large and very large calculated
140 as 0.20, 0.60, 1.2 and 2.0 of the observed between-teams standard deviation for each KPI
141 in 2016; this standard deviation was estimated from the random effects and over-
142 dispersed Poisson or logistic variance in the log- or logistic-transformed domain
143 (Hopkins, 2016). Uncertainty in the standardized effects arising from uncertainty in the
144 standardising standard deviation was assumed to be negligible, owing to the large number
145 of games from which the standard deviation was derived (Hopkins & Batterham, 2019).
146 Uncertainty in each effect was expressed as 90% confidence limits and as probabilities
147 that the true effect was substantially positive and negative (derived from standard errors,
148 assuming a normal sampling distribution). These probabilities were used to make a
149 qualitative probabilistic non-clinical Bayesian inference with a disperse uniform prior
150 about the true effect (Hopkins & Batterham, 2018): if the probabilities of the effect being
151 substantially positive and negative were both >5%, the effect was reported as unclear; the
152 effect was otherwise clear and reported with the probability that it was either substantial
153 or trivial, usually whichever was the larger. The scale for interpreting the probabilities
154 was as follows: 25–75%, possible; 75–95%, likely; 95–99.5%, very likely; >99.5%, most
155 likely. To account for inflation of Type 1 error, only effects clear with 99% confidence
156 intervals were highlighted (Liu, Hopkins, & Gomez, 2015). Visual inspection of residuals
157 vs predicted and residuals vs predictors showed no evidence of non-uniformity and non-
158 linearity.

159 **Results:**

160 The mean and standard deviation for each KPI in 2016 are shown in Table 1 along with

161 the secular trend and the effects of the difference in ranking and the changes in rules and
162 competition format in 2008 and 2011. Figure 1 shows the mean and standard deviations
163 for each year and the secular trend using the KPI carries as an example. The secular trend
164 represents clear small to moderate increases for the majority of the KPIs, with only
165 penalties conceded and tackles showing clear decreases. The remaining KPIs showed
166 trivial changes that were unclear, except for turnovers conceded. The changes in rules
167 and competition format had clear substantial effects on all KPIs, ranging from trivial (e.g.,
168 offloads) to mainly small increases (e.g., carries) and decreases (e.g., clean breaks). The
169 difference in ranking had clear substantial effects on all KPIs, (increase in positive KPIs
170 and decrease in negative KPIs) ranging from trivial (e.g., carries) to moderate (e.g., tries).

171

172 ***Table 1 near here***

173

174 ***Figure 1 near here***

175

176 The pure effects of the away-match disadvantage and the combined effect of flight
177 duration and time-zones crossed for longest travel in both directions on each KPI are
178 presented in Table 2. Figure 2 shows these effects for each year and the overall trend
179 using the KPI carries as an example. The pure effects of the away-match disadvantage
180 were mostly clear and trivial for 2016 and the 11-year trend. The travel effects in 2016
181 were trivial to moderate for both directions of travel and generally clearly negative
182 travelling eastward and either positive (e.g., tries) or negative (e.g., carries) travelling
183 westward. Trends were generally negative travelling eastward and either positive or

184 negative travelling westward, although mostly unclear for both directions of travel, and
185 ranging from trivial to moderate.

186

187 ***Table 2 near here***

188

189 ***Figure 2 near here***

190

191 The analyses of the individual differences between teams for each KPI produced mostly
192 unclear results. However, there was some evidence of small differences between teams
193 for some of the KPIs, including carries and passes, after travelling east (data not shown).

194

195 **Discussion:**

196 This study analysed the effects of travel on team KPIs in Super Rugby over 11 years. The
197 main focus was the effects of long-haul travel consisting of 24 hours of travel across 12
198 time-zones, which were derived from an analysis of all available KPIs from all Super
199 Rugby matches. By doing so, it was possible to properly adjust for secular trend, effects
200 of rule and format changes, and the away-match disadvantage. The effects of the long-
201 haul travel were predicted from a model based on the assumption that the travel and time-
202 zone shift had simple linear numeric effects. The apparent absence of non-uniformity in
203 the plots of residuals justified this assumption.

204 The positive secular trends for most of the KPIs show that, over time, players
205 increased the number of actions performed during matches. As several of these KPIs, for

206 example carries, clean breaks and defenders beaten, require high intensity efforts, these
207 trends are consistent with the evolution of rugby toward a more physical game, despite
208 clear reductions due to the changes in rules and competition format. Rugby union is a
209 sport in continual evolution, with rules changed to increase safety of players as they
210 become stronger and faster (WorldRugby, 2018). Similarly, Super Rugby expanded to
211 include new countries and changed the competition format to make the game more
212 entertaining and lucrative (SuperRugby, 2015). Despite the changes in rules, the moderate
213 increases in clean breaks, defenders beaten, and tries, along with a similar increase in
214 missed tackles, show that the game shifted toward a more offensive and physically
215 demanding style, while the moderate decrease in penalties conceded could be due to the
216 effects of changes in rule, an improvement in players' discipline or different
217 interpretations of the rules by match officials. The difference in ranking, as expected, had
218 a substantial positive impact (up to moderate) on most of the KPIs including metres and
219 clean breaks.

220 The away-match disadvantage is due to a combination of factors, including
221 changes in the psychological state of athletes (Carron, Loughhead, & Bray, 2005). When
222 isolated from the travel component in our analyses, the away-match disadvantage had
223 generally only trivial effects on performance. The estimates were based on the reasonable
224 assumption that the disadvantage was the same for matches played either overseas or after
225 short, internal travel. If the away match disadvantage was greater overseas, for example,
226 then the effects of travel would have been biased high. Unfortunately, all matches after
227 long-haul travel are away matches and there is no way to separately estimate an away
228 disadvantage in a remote location. Previous studies showed the existence of an away-
229 match disadvantage in Super Rugby on points scored (Du Preez & Lambert, 2007) and
230 match outcomes (Morton, 2006) with adjustment for a travel effect in the first of these

231 studies. Given the mainly trivial effects of the away-match disadvantage in our study, we
232 suggest that playing away from home could impact match results by affecting tactical and
233 strategic aspects of Super Rugby matches rather than technical skills and physical
234 performance of players.

235 Throughout the monitored period the changes in KPIs are consistent with an
236 impairment of performance following eastward long-haul travel across multiple time-
237 zones, while performance did not change or slightly improved following westward travel.
238 These findings support the idea that travelling east is usually more detrimental than
239 travelling west. Eastward travel requires a phase advance of circadian rhythms while
240 travelling westward requires a phase delay. As circadian rhythms are, on average, slightly
241 longer than 24 h (Czeisler et al., 1999; Srinivasan et al., 2010), the human body shows a
242 natural tendency to drift slightly each day and, therefore, is more capable to cope with a
243 delay than an advance in time (Eastman & Burgess, 2009). Thus, after eastward travel,
244 the symptoms of jet lag are more severe (Herxheimer & Petrie, 2002; Srinivasan et al.,
245 2010), the time required to recover is longer (Eastman & Burgess, 2009), and
246 performance is impaired (Fowler et al., 2017).

247 Rugby is an intermittent high intensity team sport (Gill, Beaven, & Cook, 2006)
248 and fatigue may negatively influence players' performance (Kempton, Sirotic, Cameron,
249 & Coutts, 2013). As the changes due to travel were more substantial for KPIs requiring
250 repeated high intensity efforts, e.g., carries (Sayers & Washington-King, 2005), although
251 not directly measured, fatigue may be the key factor that impaired performance after
252 travel. Even if a full night of rest is usually enough to recover from travel fatigue (Reilly
253 et al., 1997), fatigue related to jet lag affects performance for several days (Waterhouse,
254 Reilly, Atkinson, & Edwards, 2007). The 11-year trends for the travel effects showed that
255 in recent years the impairment in performance was more substantial for some KPIs,

256 especially for eastward travel. A possible explanation is that there was a gradual decrease
257 in the time between arrival and match-day, resulting in inadequate time to fully recover,
258 but data to support this explanation are not available. The shift toward a more demanding
259 game style may also have interacted with travel to increase player fatigue and affected
260 performance. As there was evidence of small differences in the between-team individual
261 responses to travel following east bounded flights, fatigue has the potential for being the
262 most important mediator for the effects of travel on KPIs.

263 A possible limitation of this study is that match outcomes (win or lose) have not
264 been included. A decline in team KPI after trans-meridian travel may have affected the
265 chance of a team to win a match. However, the main aim of this study was to assess
266 changes in performance indicators and, as winning is not just a matter of numbers,
267 changes in KPI may not be indicative of changes in winning capability. As several
268 components contribute in determining the outcome of a match, the introduction of the
269 match result in the analysis may have only introduced an element of noise. It might be
270 that players and teams performed worse in terms of sheer ‘match statistic’ after travel but
271 perform better overall (i.e. won the match). Even if an improvement in KPIs influenced
272 the chance of winning matches in Rugby 7’s (Higham, Hopkins, Pyne, & Anson, 2014)
273 that may not be true for Rugby Union. Rugby Union is a peculiar game where territory
274 occupation is as important as ball possession to achieve a victory (Bishop & Barnes,
275 2013) especially when compared with rugby 7’s where the disproportion between the
276 number of players and the field dimension may enhance the importance of individual
277 action in achieving victory. All the KPIs analysed were related to situations of ball
278 possession (e.g., clean breaks) or non-possession (e.g., tackles), set pieces (scrums and
279 lineouts) and discipline (penalties conceded). A reduction on these indicators does not

280 automatically lead to a less functional occupation of the territory and therefore may not
281 impact the ability of a team to win.

282 In summary, the findings of the present study suggest that long-haul travel and
283 the increased physical demand of the game negatively impact players and team KPIs
284 when overseas. Teams that underperform whilst overseas are less likely to finish high in
285 the ladder and compete in the finals, which may also have a negative impact on team
286 finance. As the increased physical demand of the game cannot be directly controlled,
287 teams in Super Rugby should focus on implementing adequate recovery strategies to
288 reduce the effects of travel. The findings of this research, although not directly
289 translatable, can be of interest for all the coaches and support staff in sports that require
290 international travel to compete.

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294

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Table 1. Mean and standard deviation for each KPI in 2016 along with the secular trend and the effects of the difference in ranking and of the changes in rules in 2008 and 2011. Effects are reported in percent unit with 90% confidence limits.

	Mean \pm SD in 2016 (n=284)	Secular trend, \pm CL ^a	Difference in ranking, \pm CL ^a	Effect of rule changes	
				from 2008, \pm CL ^a	from 2011, \pm CL ^a
Carries	107 \pm 23	7.0, \pm 9.0 ^{S*}	2.0, \pm 1.7 ^{T^{ooo}}	14.6, \pm 5.0 ^{S****}	7.5, \pm 5.0 ^{S**}
Clean breaks	10.2 \pm 5.4	77.4, \pm 152.2 ^M	26.7, \pm 5.5 ^{S****}	-28.2, \pm 27.4 ^{M**}	-7.8, \pm 40.7 ^T
Conversions	2.3 \pm 1.9	58.1, \pm 45.3 ^{M****}	56.7, \pm 8.2 ^{M****}	2.4, \pm 14.4 ^{T^{oo}}	-24.9, \pm 11.7 ^{S**}
Defenders beaten	19.7 \pm 7.8	58.6, \pm 74.5 ^{L**}	11.6, \pm 3.4 ^{S****}	-9.4, \pm 20.0 ^S	12.5, \pm 28.5 ^S
Kicks in play	22.0 \pm 7.2	-0.0, \pm 30.0 ^T	2.9, \pm 2.9 ^{T^{ooo}}	n/a	-11.8, \pm 13.8 ^{S*}
Lineouts won %	87 \pm 11	10.0, \pm 4.0 ^{M****}	2.0, \pm 1.0 ^{T^{oo}}	n/a	-2.0, \pm 2.0 ^{T^{oo}}
Metres	430 \pm 140	2.8, \pm 38.5 ^T	12.9, \pm 2.5 ^{S****}	10.0, \pm 24.1 ^S	-6.8, \pm 18.8 ^S
Offloads	10.8 \pm 5.2	41.5, \pm 34.1 ^{M****}	9.6, \pm 4.0 ^{S*}	3.0, \pm 12.3 ^{T^{oo}}	-2.3, \pm 13.0 ^T
Passes	140 \pm 35	10.7, \pm 14.9 ^{S*}	3.9, \pm 2.0 ^{T^{oo}}	6.4, \pm 7.1 ^{S*}	5.3, \pm 7.9 ^{S*}
Rucks won %	94.0 \pm 3.1	0.0, \pm 2.0 ^T	0.0, \pm 2.0 ^{T^{oooo}}	-2.0, \pm 1.0 ^{S**}	1.0, \pm 1.0 ^{T*}
Scrum won %	89 \pm 15	-1.0, \pm 8.0 ^S	2.0, \pm 1.0 ^{T^{oo}}	-1.0, \pm 5.0 ^T	-2.0, \pm 4.0 ^{T*}
Tackles	104 \pm 28	-9.5, \pm 19.0 ^S	0.5, \pm 1.9 ^{T^{oooo}}	19.5, \pm 12.1 ^{M****}	11.0, \pm 12.7 ^{S**}
Tries	3.2 \pm 2.2	53.0, \pm 38.5 ^{M****}	59.5, \pm 7.5 ^{M****}	2.8, \pm 12.7 ^{T^{oo}}	-25.2, \pm 10.3 ^{S****}
Missed tackles	19.7 \pm 7.8	56.7, \pm 67.9 ^{M**}	-10.3, \pm 2.6 ^{S****}	-9.7, \pm 18.5 ^S	10.8, \pm 26.0 ^S
Penalties conceded	9.3 \pm 3.0	-33.7, \pm 42.5 ^M	0.8, \pm 2.3 ^{T^{oooo}}	13.0, \pm 33.1 ^S	14.8, \pm 38.8 ^S
Turnovers Conceded	16.4 \pm 4.0	3.1, \pm 30.5 ^T	-3.3, \pm 1.9 ^{T^{ooo}}	6.4, \pm 14.9 ^S	-4.0, \pm 15.5 ^T

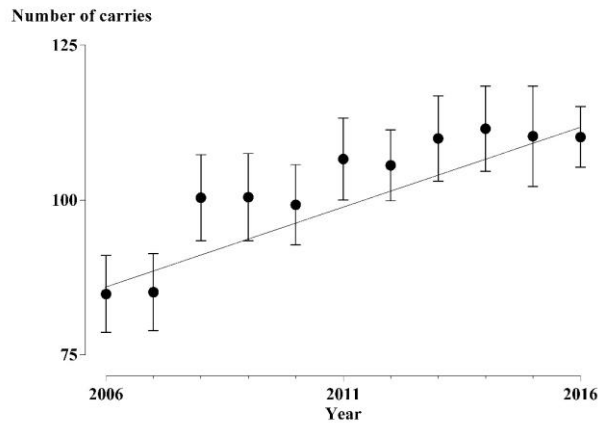
Superscripted letters indicate effect size as follows: ^TTrivial, ^SSmall, ^MModerate, ^LLarge.

Symbols indicate the probability of an effect being substantial or trivial (whichever was the larger).

Asterisks indicate clear substantial effects as follows: *possibly, **likely, ***very likely, ****most likely; larger asterisks indicate effects clear at the 99% level.

Degree symbols indicate trivial effects as follows: ^opossibly, ^{oo}likely, ^{ooo}very likely, ^{oooo}most likely; larger degree symbols indicate effects trivial at the 99% level.

410 Figure 1. Example of a secular trend in Super Rugby matches using the KPI carries. Data
411 points are means and standard deviations from the by year analysis. The continuous line
412 represent the secular trend.
413



414

Table 2 – Pure effects of the away-match disadvantage and of eastward and westward long-haul travel, 12 time-zones, 24 h travel on team KPIs in 2016 and the 11-year trend over the monitored period (2006-2016). Predicted values are expressed as percent variation with 90% confidence limits.

	Means in 2016, \pm CL ^a			11-year trend, \pm CL ^a		
	Away-match disadvantage	Travel east	Travel west	Away-match disadvantage	Travel east	Travel west
Carries	-3.2, \pm 2.5 ^{T^{oo}}	-9.3, \pm 6.4 ^{S***}	-9.4, \pm 6.6 ^{S***}	3.4, \pm 5.1 ^{T*}	-14.3, \pm 11.1 ^{M**}	-1.3, \pm 13.7 ^T
Clean breaks	-16.0, \pm 5.4 ^{S***}	-21.9, \pm 14.4 ^{S***}	8.4, \pm 18.3 ^{T*}	-6.2, \pm 11.2 ^{T^{oo}}	-29.9, \pm 22.4 ^{S**}	22.2, \pm 39.9 ^{S*}
Conversions	-19.6, \pm 7.1 ^{S***}	-12.2, \pm 21.8 ^{T*}	21.2, \pm 27.6 ^{S*}	-3.8, \pm 15.7 ^{T^{oo}}	5.8, \pm 48.7 ^T	11.0, \pm 48.2 ^T
Defenders beaten	-12.8, \pm 3.8 ^{S***}	-11.3, \pm 10.9 ^{S*}	3.0, \pm 12.2 ^T	-9.4, \pm 7.9 ^{S*}	-10.5, \pm 21.0 ^S	18.5, \pm 28.8 ^{S*}
Kicks in play	-2.1, \pm 4.4 ^{T^{ooo}}	0.0, \pm 11.9 ^T	-0.5, \pm 12.0 ^T	1.4, \pm 11.1 ^T	-15.5, \pm 24.2 ^S	-3.0, \pm 29.6 ^T
Lineouts won %	0.0, \pm 2.0 ^{T^{ooo}}	0.0, \pm 4.0 ^T	-2.0, \pm 4.0 ^T	1.0, \pm 4.0 ^T	-3.0, \pm 10.0 ^S	-1.0, \pm 10.0 ^T
Metres	-8.6, \pm 3.1 ^{S***}	-14.8, \pm 8.0 ^{S****}	0.4, \pm 9.2 ^T	-2.2, \pm 6.4 ^{T^{oo}}	-21.0, \pm 13.5 ^{M***}	-3.8, \pm 17.3 ^T
Offloads	-6.4, \pm 5.0 ^{T^{oo}}	-11.2, \pm 13.3 ^{S*}	-1.4, \pm 14.3 ^T	-4.3, \pm 9.9 ^{T^{oo}}	-11.1, \pm 24.9 ^S	11.3, \pm 31.7 ^T
Passes	-2.3, \pm 2.7 ^{T^{ooo}}	-10.0, \pm 6.9 ^{S***}	0.2, \pm 7.6 ^T	3.9, \pm 5.4 ^{T*}	-11.1, \pm 12.4 ^{S**}	4.9, \pm 15.2 ^T
Rucks won %	0.0, \pm 0.0 ^{T^{oo}}	0.0, \pm 1.0 ^T	0.0, \pm 1.0 ^T	1.0, \pm 1.0 ^{T*}	0.0, \pm 2.0 ^T	-1.0, \pm 2.0 ^T
Scrum won %	-2.0, \pm 2.0 ^{T*}	3.0, \pm 5.0 ^{T*}	-6.0, \pm 4.0 ^{S***}	-2.0, \pm 3.0 ^{T*}	-2.0, \pm 8.0 ^T	-10.0, \pm 8.0 ^{M**}
Tackles	2.9, \pm 3.3 ^{T^{oo}}	5.6, \pm 8.9 ^{S*}	10.3, \pm 9.6 ^{S***}	-4.8, \pm 5.7 ^{T*}	-10.0, \pm 13.7 ^{S*}	26.3, \pm 21.1 ^{M***}
Tries	-17.7, \pm 6.1 ^{S***}	-18.3, \pm 17.1 ^{S*}	20.3, \pm 22.8 ^{S*}	2.1, \pm 13.8 ^{T^{oo}}	-10.9, \pm 33.6 ^T	21.1, \pm 43.7 ^S
Missed tackles	13.5, \pm 5.2 ^{S***}	12.0, \pm 13.3 ^{S*}	9.1, \pm 13.6 ^{S*}	6.2, \pm 9.6 ^{T*}	-1.7, \pm 22.5 ^T	34.9, \pm 34.8 ^{M**}
Penalties conceded	6.4, \pm 4.6 ^{T*}	-6.5, \pm 11.0 ^{T*}	6.1, \pm 12.3 ^{T*}	-0.8, \pm 7.7 ^{T^{oo}}	-9.4, \pm 18.5 ^S	-4.1, \pm 20.0 ^T
Turnovers conceded	0.6, \pm 3.3 ^{T^{ooo}}	4.7, \pm 9.0 ^{T*}	-3.8, \pm 8.7 ^{T*}	0.7, \pm 6.0 ^{T^{oo}}	-0.4, \pm 15.3 ^T	0.3, \pm 16.6 ^T

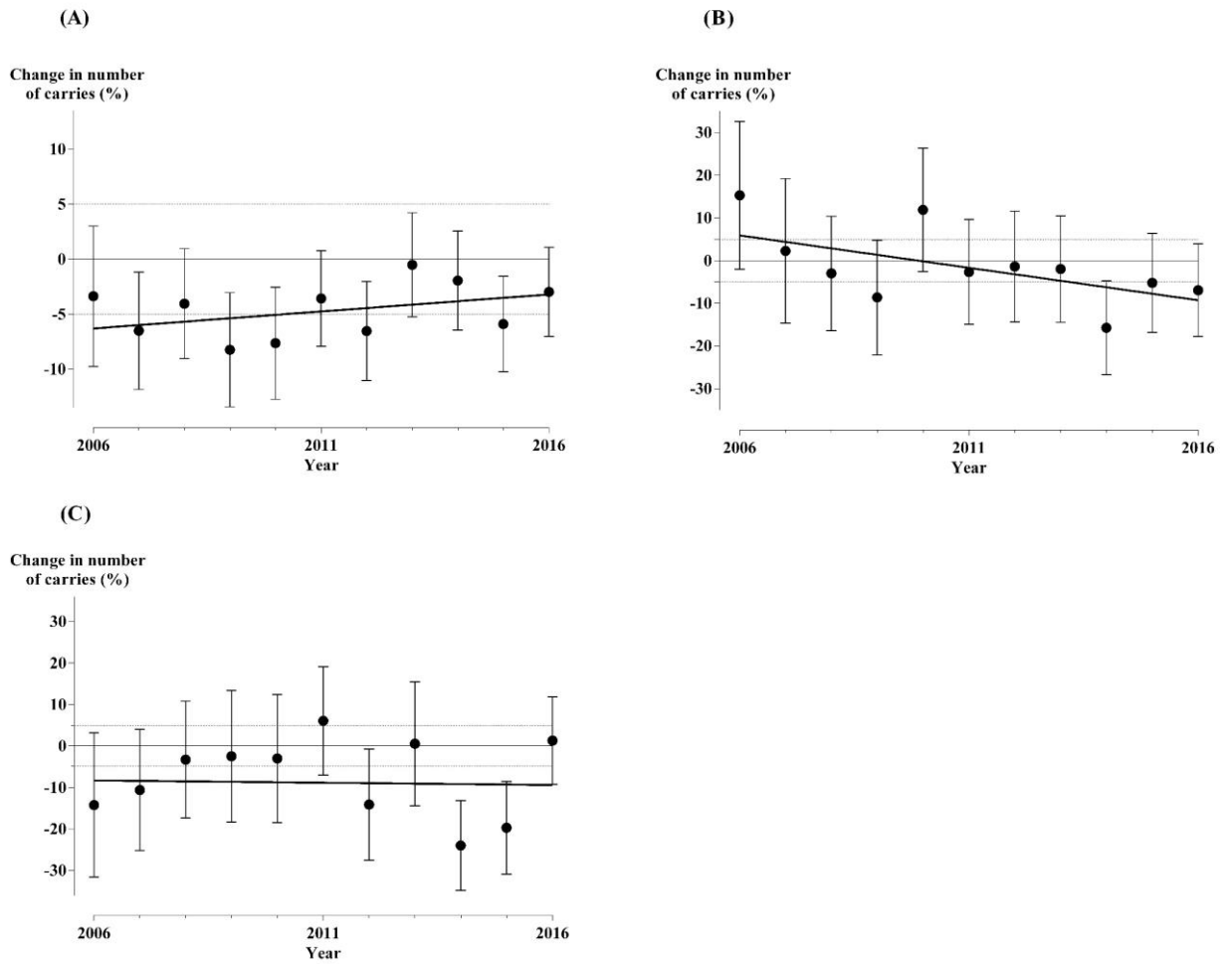
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415 Figure 2. Pure effects of the away-match disadvantage (A) and effects of eastward (B)
 416 and westward (C) long-haul travel (12 time-zones, 24 h travel) on the number of carries,
 417 expressed as a percent variation, in Super Rugby matches. Data points are the predicted
 418 values from by-year analysis, with 90% confidence limits. Continuous lines were derived
 419 from the regression analysis of all data. Dotted lines are thresholds for the smallest
 420 important effect.



421