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Individual and combined effects of acute and chronic running loads on injury risk in elite Australian footballers

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A model that takes into account the current workload, and the workload the athlete has been prepared for, as an acute:chronic workload ratio has been previously used as a novel way to monitor training load and injury risk. Fifty-nine elite Australian football players from one club participated in this 2-year study. Global Positioning System technology was used to provide information on running workloads of players. An injury was defined as any non-contact "time-loss" injury. One-week (acute), along with 4-week (chronic) workloads were calculated for a range of variables. The size of the acute workload in relation to the chronic workload was calculated as an acute:chronic workload ratio. An acute:chronic workload ratio of >2.0 for total distance during the in-season was associated with a 5 to 8-fold greater injury risk in the current [relative risk (RR) = 8.65, P = 0.001] and subsequent week (RR = 5.49, P = 0.016). Players with a high-speed distance acute:chronic workload ratio of >2.0 were 5–11 times more likely to sustain an injury in the current (RR = 11.62, P = 0.006) and subsequent week (RR = 5.10, P = 0.014). These findings demonstrate that sharp increases in running workload increase the likelihood of injury in both the week the workload is performed, and the subsequent week.

Australian Football (AF) is an intermittent team sport, requiring players to perform repeated high-speed (i.e., sprinting, running) and low-speed (i.e., jogging, walking) movements interspersed with physical contacts throughout a match (Coutts et al., 2010; Gray & Jenkins, 2010). The ability of players to maintain the required level of physical activity throughout a match is vital for successful performance, with global positioning system (GPS) devices regularly used to monitor activity profiles during competition (Aughey, 2010; Coutts et al., 2010; Wisbey et al., 2010). An increased emphasis has been placed on quantifying workloads during training and competition, and the relationship between workload and injury (Gabbett, 2004, 2010; Gabbett & Domrow, 2007; Gabbett & Jenkins, 2011; Rogalski et al., 2013; Hulin et al., 2014, 2016a). Indeed, some have promoted the restriction of players' workloads in an attempt to limit the training-related stresses, thereby potentially reducing the number of injuries sustained (Gamble, 2013).

Originally proposed by Banister (Banister et al., 1975; Banister & Calvert, 1980; Chiu & Barnes, 2003), the fitness-fatigue model states that the training stress placed on an athlete results in two contrasting responses – fitness and fatigue. Based on these early investigations, a novel model comparing acute workload (i.e., 1-week workload) and chronic workload (i.e., 4-week rolling average acute workload) has been used to predict performance and injury (Hulin et al., 2014, 2016a, b; Gabbett, 2016). Preparedness represents the difference between a positive function (i.e., fitness) and a negative function (i.e., fatigue), where chronic workload represents "fitness" and acute workload represents "fatigue" (Gabbett, 2016). The fitness after-effect results in a positive physiological response and in turn improved performance (Banister et al., 1975; Banister & Calvert, 1980; Chiu & Barnes, 2003), whereas the fatigue after-effect results in a negative physiological response, decreased performance, and potentially a subsequent increase in injury risk (Hulin et al., 2014; Gabbett et al., 2016; Hulin et al., 2016a, b). The difference between the positive physiological response and the negative physiological response provides either a low (chronic workload is greater than the acute workload) or high (acute workload is greater than the chronic workload) acute:chronic workload ratio (Hulin et al., 2014, 2016a; Gabbett, 2016).

In sub-elite rugby league players, Gabbett and Domrow (2007) demonstrated an increase in the likelihood of injury during the pre-season (odds ratio

[OR] = 2.12, $P = 0.01$), early competition (OR = 2.85, $P = 0.01$), and late competition (OR = 1.50, $P = 0.04$) phases, for every increase in a log (150 arbitrary units [au]) of workload, measured using the session rating of perceived exertion (RPE). Rogalski et al. (2013) found that larger 1-weekly (>1750 au, OR = 2.44–3.38), 2-weekly (>4000 au, OR = 4.74), and previous-to-current week (>1250 au, OR = 2.58) changes in session RPE workload were significantly related to increased non-contact soft tissue injury risk when compared with reference groups of <1250 au, <2000 au, and <250 au, respectively. Moreover, during a pre-season training block, 3-weekly total distance covered (OR = 5.49, $P = 0.008$) and 3-weekly sprint distance (OR = 3.67, $P = 0.074$) were associated with a higher non-contact soft tissue injury risk (Colby et al., 2014). While these studies compared injury risk with either absolute workload (e.g., 1-week, or 3-week), or previous-to-current week changes in workload, no study has investigated the comparison of acute and chronic running workloads in AF. In elite cricket fast bowlers, Hulin et al. (2014) reported that large increases in acute bowling workload (i.e., balls bowled), represented by a high acute:chronic workload ratio, were associated with an increased risk of injury in the week following exposure. Furthermore, in a cohort of elite rugby league players, a very-high acute:chronic workload ratio (≥2.11) for total distance, measured via GPS technology demonstrated the greatest risk of injury in the current (16.7% risk of injury) and subsequent (11.8% risk of injury) week (Hulin et al., 2016a). Therefore, it is important to consider the delayed effect of the previous weeks' workload when analysing workload-injury relationships.

To date, there is limited research that has investigated the relationship between acute and chronic running workloads and the acute:chronic workload ratio in elite Australian footballers. Therefore, the aim of the present study was to investigate if acute and chronic running workloads, and the acute:chronic workload ratio were associated with subsequent injury risk in elite Australian footballers.

Materials and methods

Fifty-nine elite AF players from one club (mean ± SD age, 23 ± 4 years; height, 189 ± 7 cm; mass, 88 ± 8 kg) participated in this study. Data were collected over the course of two Australian Football League (AFL) seasons. Of the two seasons, 33 (56%) participants competed in both seasons and 26 (44%) competed in one season – equating to a total of 92 individual seasons. Each season consisted of a 16-week pre-season period including running and football-based sessions, followed by a 23-week in-season period. All experimental procedures were approved by The Australian Catholic University Human Research Ethics Committee.

Workload data were collected via GPS technology, which provided information on the training and match workloads of players. The GPS units sampled at 10 Hz (Optimeye S5; Catapult Innovations, Melbourne, Victoria, Australia) and also housed a tri-axial accelerometer, gyroscope, and magnetometer sampling at 100 Hz. Workload variables consisted of; (a) total distance (m), (b) low-speed distance (0.00–6.00 km/h), (c) moderate-speed distance (6.01–18.00 km/h), (d) high-speed distance (18.01–24.00 km/h), (e) very high-speed distance (>24.00 km/h), and (f) player load (au). This technology has demonstrated adequate validity and reliability when measuring velocity, distance, acceleration, and player load (Boyd et al., 2011; Varley et al., 2012). Player load was measured as a modified vector magnitude using accelerometer data from each vector (X, Y, and Z axis), and was expressed as a measure of "load" on each player by detecting the rate of change in each vector (Boyd et al., 2011). Medical staff at the football club classified all injuries, with injury reports maintained and updated daily throughout the season. An injury was defined as any non-contact "time-loss" injury obtained during training or competition that resulted in a missed training session or missed game (Rogalski et al., 2013).

Data were categorized into weekly blocks from Monday through Sunday. One-week data represented acute workload, while a four-week average of acute workload represented chronic workload. The acute:chronic workload ratio was calculated by dividing the acute workload by the chronic workload (Hulin et al., 2014, 2016a, b; Gabbett, 2016). Where the acute workload was greater than the chronic workload, a high acute:chronic workload ratio was calculated, and where the chronic workload was greater than the acute workload, a low acute:chronic workload ratio was calculated. A player who completed no external work (i.e., 0 meters run) would not have produced a workload, and therefore would not have produced a risk of injury for that week. These zero workload data were included in the analysis for the purpose of calculating chronic workload and exploring the risk of injury in the weeks following no work, although not considered in the week where no workload was performed. Similarly, the first 3 weeks of data in the pre-season were excluded only in the chronic workload category, until an accurate chronic workload could be calculated in the fourth week. In the event that a player participated in modified or rehabilitation field training, all workload data were included in the analysis.

Data were categorized into discrete ranges for each variable based on the workload accumulated per week. Workload variables were divided into independent logical increments to enhance the real-world application of these data. These increments were the same when calculating acute and chronic workloads and injury likelihoods. The acute:chronic workload ratio was divided into the following ranges; (a) very low, ≤0.49, (b) low, 0.50–0.99, (c) moderate, 1.0–1.49, (d) high, 1.5–1.99, and (e) very high, ≥2.0 (Hulin et al., 2014). Injury likelihoods were calculated based on the total number of injuries sustained relative to the total number of exposures to each workload range. Injury likelihoods and relative risks (RR) were calculated for the present week, and subsequent week (Bahr & Holme, 2003).

Statistical analysis

Differences in workload between the pre-season period and in-season period were determined using a 1-way analysis of variance (ANOVA). The likelihood of sustaining an injury was analysed using a binary logistic regression model with significance set at $P < 0.05$. Acute workload, chronic workload, and acute:chronic workload ratio ranges were independently modeled as predictor variables, and injury/no injury as the dependent variable. The very high acute:chronic workload ratio (≥2.0) was used as the reference category for which each other category was compared. Given the practical nature of the study, magnitude-based statistics were used to determine any practically significant differences between groups (Batterham & Hopkins, 2006; Hopkins et al., 2009), along with 90% confidence intervals. Likelihoods were subsequently generated and thresholds used for assigning qualitative terms to chances were as follows: <1%, almost certainly not; <5%, very unlikely; <25%, unlikely; <50%, possibly not; ≥50%, possibly; ≥75%, likely; ≥95%, very likely; ≥99%, almost certainly (Batterham & Hopkins, 2006; Hopkins et al., 2009). The magnitude of difference was considered practically significant when the likelihood was ≥75% (Batterham & Hopkins, 2006; Hopkins et al., 2009). Prior to beginning our study, 40 players were contracted to the AFL squad. Given that on average 90% of players in an AFL club sustain a new injury in any given season (Orchard et al., 2015), the calculated number of injuries required to achieve an alpha level of 0.05 with a confidence level of 90% was 34.

Results

Over the course of the study, 40 injuries were recorded, with 18 of these injuries sustained during the pre-season period. Of these, the hamstring (44%) and thigh (27%) were the most commonly injured sites. Similarly, of the 22 injuries recorded during the in-season period, hamstring injuries (59%) were the most common, followed by calf (18%) and thigh (9%) injuries.

Descriptive statistics for all participants' external workload variables over the course of the study are shown in Table 1. Acute workloads were significantly ($P < 0.05$) higher during the pre-season period for low, high, and very high-speed distance, and player load when compared with the in-season period. Similarly, chronic workloads were significantly ($P < 0.05$) higher for high and very high-speed distance during the pre-season period. However, chronic workloads for total, low, and moderate-speed distance were significantly ($P < 0.05$) higher during the in-season period. The acute:chronic workload ratio was significantly ($P < 0.05$) higher for total, low-, moderate-, high-, and very high-speed distance, along with player load during the pre-season period when compared with the in-season period.

Current week

The relationships between acute and chronic workloads and the risk of injury in the current week during the pre-season period are shown in Fig. 1a and b, respectively. No significant relationships (likelihood ≤75%, $P > 0.05$) were observed between acute and chronic workloads and injury risk during the pre-season. During the in-season period in the current week, a total distance chronic workload of

Table 1. Descriptive statistics for all participants' external workload variables over the course of the study

Workload variable	Pre-season			In-season			Pre- vs in-season (P value)		
	Acute	Chronic	ACWR	Acute	Chronic	ACWR	Acute	Chronic	ACWR
Total distance (m)	17 905.2 ± 7376.2	14 353.9 ± 6204.8	1.45 ± 0.96	17 515.1 ± 5657.6	15 748.1 ± 4770.0	1.13 ± 0.54	0.069	0.024*	0.001*
Low-speed distance (m)	4837.0 ± 1897.8	3843.6 ± 1718.2	1.49 ± 0.95	4795.5 ± 1638.0	4348.7 ± 1301.5	1.12 ± 0.52	0.032*	0.020*	0.001*
Moderate-speed distance (m)	9248.6 ± 4131.9	7372.0 ± 3375.8	1.46 ± 0.97	9637.3 ± 3703.8	8687.4 ± 2850.3	1.14 ± 0.58	0.042*	0.006*	0.001*
High-speed distance (m)	3130.5 ± 1917.3	2584.6 ± 1359.7	1.39 ± 1.02	2058.1 ± 899.7	1852.7 ± 661.6	1.13 ± 0.57	0.001*	0.001*	0.001*
Very high-speed distance (m)	902.3 ± 746.4	728.9 ± 491.2	1.43 ± 1.13	576.6 ± 403.2	521.2 ± 305.0	1.11 ± 0.64	0.001*	0.001*	0.001*
Player load (au)	1696.13 ± 720.6	1360.4 ± 621.8	1.46 ± 0.96	1688.3 ± 541.5	1526.4 ± 477.1	1.14 ± 0.53	0.046*	0.007*	0.001*

All data are mean ± SD.

*Significantly ($P < 0.05$) different from pre-season.

ACWR = acute:chronic workload ratio. Data were calculated for all players from every main, modified, or rehabilitation session completed across the pre- and in-season period.

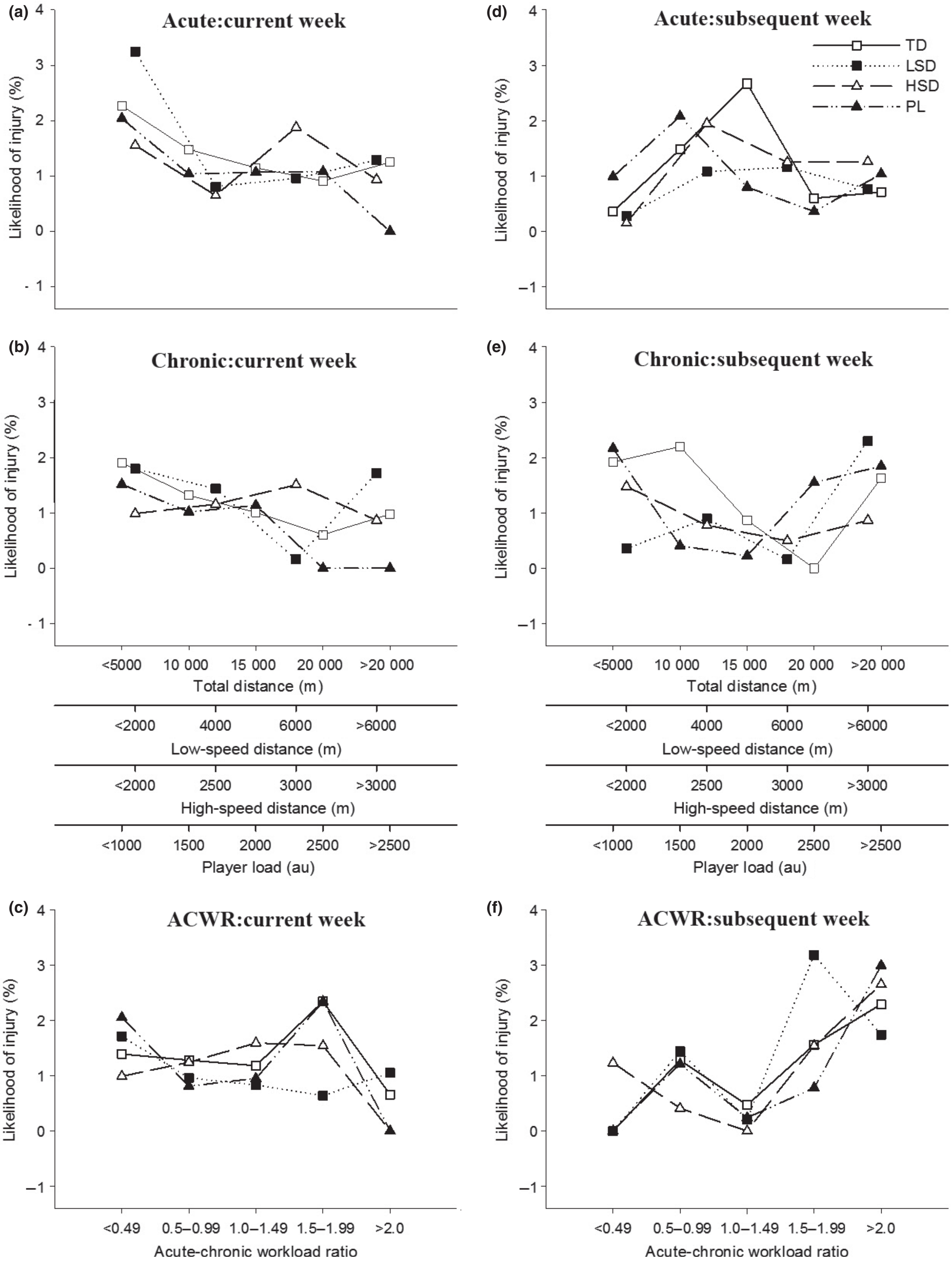

Fig. 1. Likelihood of injury at acute (a) and chronic (b) external workloads, and acute:chronic workload ratio [ACWR] (c) for the current week, and acute (d) and chronic (e) external workloads, and acute:chronic workload ratio [ACWR] (f) for the subsequent week, during the pre-season. TD = Total distance; LSD = Low-speed distance; HSD = High-speed distance; PL = Player Load.

>20 000 m was associated with a lower risk of injury than a total distance chronic workload <5000 m [RR = 0.15 (90% CI: 0.08–0.29); $P = 0.034$; 98.1%, very likely] (Fig. 2b). No other significant relationships were observed between acute and chronic workloads and injury risk in the current week during the season.

During the in-season period in the current week, players with an acute:chronic workload ratio of >2.0 for total distance were 5–8 times more likely to sustain an injury than players with an acute:chronic workload ratio of <0.49 [RR = 7.98 (CI: 5.86–10.88); $P = 0.015$; 99.2%, almost certainly], and between 0.5 and 0.99 [RR = 5.04 (CI: 4.16–6.11); $P = 0.012$; 99.3%, almost certainly] (Fig. 2c). Furthermore, players with an acute:chronic workload ratio >2.0 for low-speed [RR = 9.06 (CI: 7.78–10.56); $P = 0.007$; 99.6%, almost certainly] and moderate-speed distance [RR = 10.98 (CI: 10.73–11.25); $P = 0.002$; 99.9%, almost certainly] had an increased likelihood of injury in comparison with players who recorded an acute:chronic workload ratio of 0.50–0.99 (Fig. 2c). Similarly, an acute:chronic workload ratio of >2.0 for high-speed distance was associated with a 6–12 times greater injury risk than acute: chronic workload ratios of <0.49 [RR = 11.62 (CI: 10.04–13.45); $P = 0.006$; 99.7%, almost certainly], 0.50–0.99 [RR = 9.63 (CI: 9.21–10.07); $P = 0.002$; 99.9%, almost certainly], and 1.0–1.49 [RR = 6.54 (CI: 6.19–6.92); $P = 0.003$; 99.8%, almost certainly]. Players with a player load acute:chronic workload ratio of >2.0 had a greater risk of injury than players with a player load acute:chronic workload ratio of 0.50–0.99 [RR = 6.27 (CI: 5.62–6.00); $P = 0.006$; 99.7%, almost certainly] and 1.0–1.49 [RR = 7.72 (CI: 7.57–7.88); $P = 0.001$; 99.9%, almost certainly] (Fig. 2c). Collectively, these results demonstrate that a large spike in acute workload, resulting in a very high (>2.0) ACWR, during the in-season period is associated with a significant increase in injury risk during the current week.

Subsequent week

During the subsequent week in the pre-season period, a high acute workload >20 000 m for total distance was associated with a decreased likelihood of injury [RR = 0.27 (CI: 0.17–0.41); $P = 0.033$; 98.1%, very likely] when compared with a moderate acute workload of 10 000–15 000 m. No other significant relationships (likelihood ≤75%, $P > 0.05$) were observed between acute workloads and injury risk in the subsequent week during the pre-season. The likelihood of injury for selected acute and chronic workload running variables in the subsequent week during the in-season period is shown in Fig. 2d and e. Higher acute workloads for player load >2500 au [RR = 2.02 (CI: 1.47–2.76); $P = 0.045$; 97%, very likely] were coupled with an increased injury risk. A high chronic workload >20 000 m for total distance was associated with a lower injury risk [RR = 0.20 (CI: 0.01–3.02); $P = 0.167$; 90.6%, likely] when compared with a low chronic workload <5000 m. Similarly, a high chronic workload >6000 m for low-speed distance was associated with a decreased likelihood of injury [RR = 0.33 (CI: 0.01–18.70), $P = 0.331$, 80.9%, likely] when compared with a low chronic workload <2000 m.

In the subsequent week during the pre-season period, an acute:chronic workload ratio of >2.0 had an increased likelihood of injury when compared with players with a lower acute:chronic workload ratio for a number of variables. When compared with an acute:chronic workload ratio of >2.0, an acute: chronic workload ratio of 1.0–1.49 for total distance [RR = 4.87 (CI: 2.33–10.21); $P = 0.047$; 97.3%, very likely], low-speed distance [RR = 8.29 (CI: 2.90–23.69); $P = 0.05$; 97.3%, very likely], and player load [RR = 12.46 (CI: 8.35–18.59); $P = 0.016$; 99.1%, almost certainly]. Similarly, an acute:chronic workload ratio of >2.0 for high-speed distance compared with an acute:chronic workload ratio of 0.50–0.99 was associated with an increased likelihood of injury [RR = 6.46 (CI: 4.63–9.02); $P = 0.018$; 99%, almost certainly] (Fig. 1f). During the in-season period, players with an acute:chronic workload ratio of >2.0 had an increased likelihood of injury when compared with players with a lower acute:chronic workload ratio. Specifically, when a player exceeded an acute: chronic workload ratio of 2.0, compared to 1.0–1.49, the likelihood of injury were increased 4- to 7-fold for total distance [RR = 5.49 (CI: 4.19–7.20); $P = 0.016$; 99.1%, almost certainly], low-speed distance [RR = 7.25 (CI: 6.44–8.16); $P = 0.006$; 99.7%, almost certainly], moderate-speed distance [RR = 7.21 (CI: 6.80–7.65); $P = 0.003$; 99.8%, almost certainly], high-speed distance [RR = 4.36 (CI: 3.50–5.43); $P = 0.015$; 99.1%, almost certainly], and player load [RR = 5.80 (CI: 4.62–7.27); $P = 0.013$; 99.3%, almost certainly] (Fig. 2f). Collectively, these findings suggest that a large spike in acute workload, resulting in a very high (>2.0) ACWR, during the in-season period was associated with a significant increase in injury risk during the subsequent week.

Discussion

Based on previous research (Banister et al., 1975; Banister & Calvert, 1980; Hulin et al., 2014), this study determined the relationships between acute and chronic workloads, the acute:chronic workload ratio and injury risk in elite Australian Footballers. When chronic workload was greater than acute

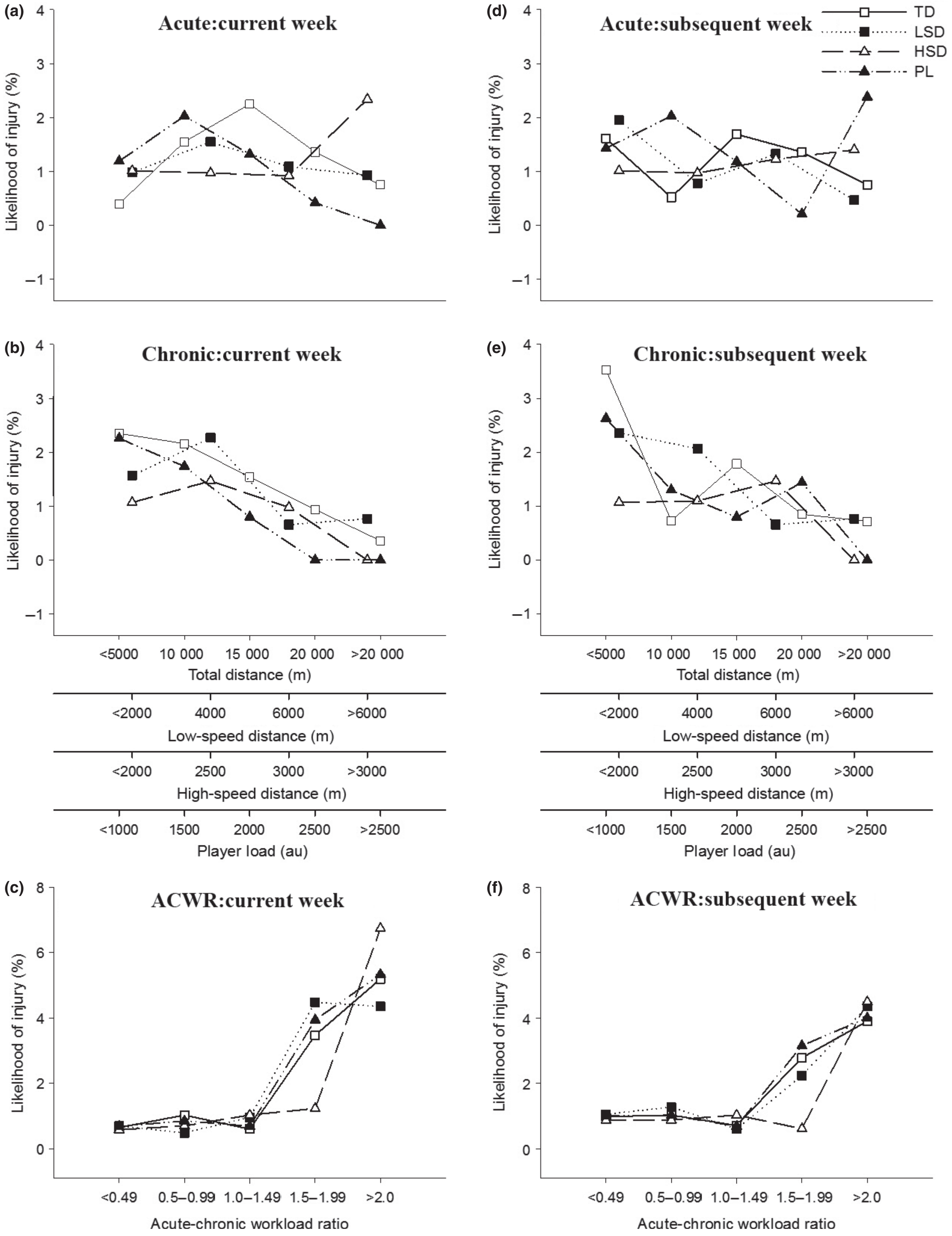

Fig. 2. Likelihood of injury at acute (a) and chronic (b) external workloads, and acute:chronic workload ratio [ACWR] (c) for the current week, and acute (d) and chronic (e) external workloads, and acute:chronic workload ratio [ACWR] (f) for the subsequent week, during the in-season period. TD = Total distance; LSD = Low-speed distance; HSD = High-speed distance; PL = Player Load.

workload, resulting in a low acute:chronic workload ratio, a lower risk of injury was observed, while sharp spikes in acute workload relative to chronic workload (>2.0), were associated with greater injury risk during the in-season period. Similar to previous findings (Hulin et al., 2014, 2016a), we found that a very high acute:chronic workload ratio of greater than 2.0 resulted in up to an 8-fold increase in the risk of non-contact soft tissue injury in the week the workload was performed. Additionally, greater increases in acute workload relative to chronic workload during the in-season resulted in a significantly increased injury risk in the subsequent week to the workload being performed. Furthermore, higher chronic workloads alone were associated with a lower injury risk in this cohort of players, suggesting that higher chronic workloads may offer a protective effect against injury. These findings demonstrate that (a) in elite AF players, sharp increases in workloads increase the likelihood of injury in both the week the workload is performed, and the subsequent week, and (b) both acute and chronic workload, and the acute:chronic workload ratio need to be modeled independently and relative to each other as a ratio to quantify injury risk.

We found significant relationships between training workloads and injury during the pre-season period. Of these, an acute:chronic workload ratio of >2.0 for total distance resulted in a 5-fold increase in injury likelihood in the subsequent week when compared with an acute:chronic workload ratio of 1.0–1.49. Similarly, a high-speed running acute:chronic workload ratio of >2.0 was associated with a 6-fold increase in the likelihood of injury in the subsequent week. Furthermore, we found that during the in-season period, a positive relationship existed between players who recorded a very high acute:chronic workload ratio (>2.0), and increased injury likelihood. This suggests that players are not as well-equipped to handle sharp spikes in workload in the current week during the season as they are during the pre-season period, possibly due to increased match and physical demands during competition along with a greater requirement for recovery (Gabbett, 2010; Hägglund et al., 2012). These findings highlight the need to increase workload progressively and systematically in order to reach high chronic workloads during both the pre- and in-season periods (Plisk & Stone, 2003; Baechle & Earle, 2008).

The present study explored the relationship between acute and chronic workloads, along with the acute:chronic workload ratio for a range of workload variables. Our findings show similar trends between different running workload variables, accelerometer loads, and injury likelihood. That is, when compared with chronic workload, greater increases in acute workload, resulting in a high acute:chronic workload ratio (>2.0), were coupled with greater injury likelihoods for all workload variables. However, we found that higher chronic workloads for total and high speed distance were associated with a decreased risk of injury, which suggests that high chronic workloads over a 4-week period may result in positive physical adaptations (Banister et al., 1975; Banister & Calvert, 1980; Hulin et al., 2014, 2016a; Gabbett, 2016), which possibly protect against non-contact, soft-tissue injury. With the continued advancement and use of monitoring technology, these novel findings provide information for strength and conditioning staff to monitor a range of acute and chronic workload variables and acute:chronic workload ratios to examine individual player's workloads and their injury risk.

Limitations

While the use of this performance model (Banister et al., 1975; Banister & Calvert, 1980) is novel, there are some limitations that warrant discussion. First, because weekly blocks were categorized from Monday to Sunday, it is possible that a player sustained an injury early in the week, and subsequently recorded a lower external workload in the current week. Second, our results may have been influenced by a small sample size recorded at extremities of the acute:chronic workload ratio (i.e., >2.0). This may be due to load monitoring systems established by the football club to minimize the number of players reaching this very high acute:chronic workload ratio. Moreover, it should be noted that the ability to draw conclusions from this study is limited due to the small number of non-contact "time-loss" injury events. The exclusion of contact injuries decreased the overall injury count, although we rationalized that an assessment of the relationship between running workloads and contact injury risk may be difficult to justify in AF. Clearly, a larger study involving more players across a larger number of teams would strengthen the present findings. Furthermore, the use of individualized speed thresholds as opposed to absolute speed thresholds currently used may provide an enhanced understanding of player workloads and consequently injury risk. Finally, it should be noted that no measures of internal workload or strength training were included in this study. It has been previously shown that well-developed strength and power may assist to reduce the risk of contact injury in professional rugby league players (Gabbett et al., 2012). Our finding of large acute spikes in external workload contributing to injury risk has implications for subsequent training. If a player is injured due to spikes in workload, it may reduce his opportunity to develop strength, which in turn may further increase his risk of injury. Therefore, the importance of identifying large acute spikes in external workload cannot be overstated. Extending upon the present study by incorporating internal workloads, including individualized speed thresholds, and exploring optimal external workload thresholds for players to minimize the risk of injury would be beneficial for coaches and strength and conditioning staff.

Perspectives

In conclusion, we investigated the relationship between acute and chronic external running workloads, the acute:chronic workload ratio, and injury risk in elite AF players. By applying a previously used model that takes into account current workload, and the workload that the athlete has been prepared for (Banister et al., 1975; Banister & Calvert, 1980; Hulin et al., 2014, 2016a), we aimed to extend on previous work which has examined the relationship between workload and injury in elite AF players (Rogalski et al., 2013; Colby et al., 2014). The results of this study demonstrate that abrupt increases in acute workload are significantly related to injury in both the current and subsequent week during the in-season period. Furthermore, it appears that high chronic workloads for total distance and low-speed distance offer a protective effect, reducing the likelihood of injury. These findings highlight the importance of individual monitoring of both acute and chronic workloads, and the acute:chronic workload ratio in order to reduce the risk of injury in elite AF players. In light of the present and previous findings (Hulin et al., 2014, 2016a), the acute:chronic workload ratio is a novel model to quantify the load an athlete has performed in the current week relative to what they have been prepared for over the past 4 weeks. Moreover, the acute:chronic workload ratio can be applied across a range of sports (i.e., football, rugby, cricket).

Key words: GPS, training, competition, workload, monitoring.

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