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Increase in the Acute

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Increase in the Acute:Chronic Workload Ratio relates to Injury Risk in Competitive Runners

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ABSTRACT

Injuries of runners reduce the ability to train and hinder competing. Literature shows that the relation between potential risk factors and injuries are not definitive, limited, and inconsistent. In team sports, workload derivatives were identified as risk factors. However, there is an absence of literature in running on workload derivatives. This study used the workload derivatives acute workload, chronic workload, and acute: chronic workload ratios to investigate the relation between workload and injury risk in running. Twenty-three competitive runners kept a daily training log for 24 months. The runners reported training duration, training intensity and injuries. One-week (acute) and 4-week (chronic) workloads were calculated as the average of training duration multiplied by training intensity. The acute:chronic workload ratio was determined dividing the acute and chronic workloads. Results show that a fortnightly low increase of the acute:chronic workload ratio (0.10–0.78) led to an increased risk of sustaining an injury ($p < 0.001$). Besides, a low increase of the acute:chronic workload ratio (0.05–0.62) between the second week and third week before an injury showed an association with increased injury risk ($p = 0.013$). These findings demonstrate that the acute:chronic workload ratio relates to injury risk.

Introduction

The yearly occurrence of time-loss injuries in middle-distance runners (64 %), long-distance runners (32 %), and marathon runners (52 %) is high [1]. Most of the injuries are associated with overuse [1, 2]. Injuries lead to a reduced training effort and the inability to compete, which can be detrimental to the career of competitive runners. Therefore, prevention of injuries is important. The Translating Research into Injury Prevention Practice (TRIPP) framework is built on the fact that the professionals only adopt the results of injury research when it helps preventing injuries [3]. The TRIPP framework defines six consecutive steps for research in building the evidence base for the prevention of injuries [3]. The first step within the TRIPP framework is to undertake injury surveillance. The second step is to identify risk and protective factors and injury mechanisms. The third step is to develop preventive measures. The fourth step is creating ideal conditions for scientific evaluation of the preventive measures. The fifth step is the description of the intervention context and development of implementation strategies and the sixth and final step is to implement the intervention in context and evaluate the effectiveness. Despite an extensive body of research on identifying risk factors, to the best of our knowledge, there is the no single study that reveals modifiable risk factors in running enabling the third step of TRIPP: development of preventive measures. In the literature, there is consensus on two non-modifiable risk factors in runners: (i) a history of running injuries and (ii) an irregular and/or absent menstruation for female runners [4, 5]. For many proposed modifiable risk factors in running, like distance, duration, frequency, pace, interval, weight, and footwear, there is an absence of clear support for an association with injury risk [4, 5]. Although workload and changes in workload are mentioned as modifiable risk factor in runners, and adjustment of the workload may prevent overuse injuries, the results on the relationship between workload as a single nonrelative factor and injuries in running are ambiguous, limited, and even inconsistent [4, 6, 7].

In contrast to the studies on running, a clear relationship between workload and injuries was identified in competitive team sports, such as Australian football [8–10], rugby [11], cricket [12], and soccer [13]. These studies found an association between an increase in the relative workload and the risk on sustaining an injury in the same or subsequent week. The relative workload was calculated as a rolling average (RA) of the acute workload in relation to the RA of the chronic workload (acute:chronic ratio). In contrast to the acute:chronic ratio, the acute and chronic workloads in isolation (i. e., not as ratios) was not consistently associated with increased injury risk [11].

Although in literature different time periods are designated as acute and chronic workload, for the acute:chronic ratio most commonly one week of workload (acute workload) compared with a four week workload (chronic workload) is reported [14]. There's a discussion whether RA or exponentially weighted moving averages (EWMA) are more suitable to use in the acute:chronic ratio [15, 16]. It is found in elite Australian Football that EWMA in higher ratio's (> 2.0) may be a more sensitive indicator [14, 15]. Although both RA and EWMA correctly identify increased injury risk [14, 15]. In the afore mentioned studies in team sports [8–13] the calculation of acute and chronic workloads were mathematically coupled, i. e., the acute workload is contained in the chronic workload, and are spuriously correlated [17]. A solution is to uncouple i. e. the acute workload is not included in the chronic workload [17]. However in practice both coupled and uncoupled lead to the same results [18].

Many studies take measures of external and internal workload, into account in the calculation of the acute:chronic ratio [11, 12, 19]. While external workload defined as the work completed independently of internal characteristics [20] (i. e. duration, distance, number of throws, speed) is significant in comprehending the physical effort of the athlete, the internal workload, or the relative physiological and psychological stress is essential in determining the workload [21]. Foster et al. (2001) proposed a monitoring tool for training load based on rating of perceived exertion (RPE) [22]. This method, known as session-RPE method (sRPE), takes into account both the intensity and the duration [22]. The combination of intensity and duration is sRPE is a valid stand-alone tool for both training and competition to calculate the workload [22, 23].

Although applying sRPE in combination with the acute:chronic workload ratio (ACWR) may be promising for identification of the impact of workload on injury risk [24], there is an absence of studies that relates sRPE based ACWR with injury risk in running. Previous studies in running on workload and injury risk defined workload as a single nonrelative factor, like duration, distance or frequency [6, 7, 11].

The aim of the present study is to investigate the sRPE based acute workload, chronic workload, ACWR, and week-to-week and fortnightly ACWR difference as modifiable risk factors, in relation to injury risk of competitive runners.

Materials and Methods

Participants

A group of 23 competitive runners (16 male, 7 female) of the same training group and the same coach participated in the study during a period of 24 months. The runners competed in race distances of 800 meters to marathon on regional (5 runners), national (15 runners), and international (3 runners) level. ▶**Table 1** shows the runners' baseline characteristics.

Written informed consent was obtained from all individual runners participating in the study. The ethics committee of University Medical Center Groningen, the Netherlands (METc 2011/186), approved the research protocols.

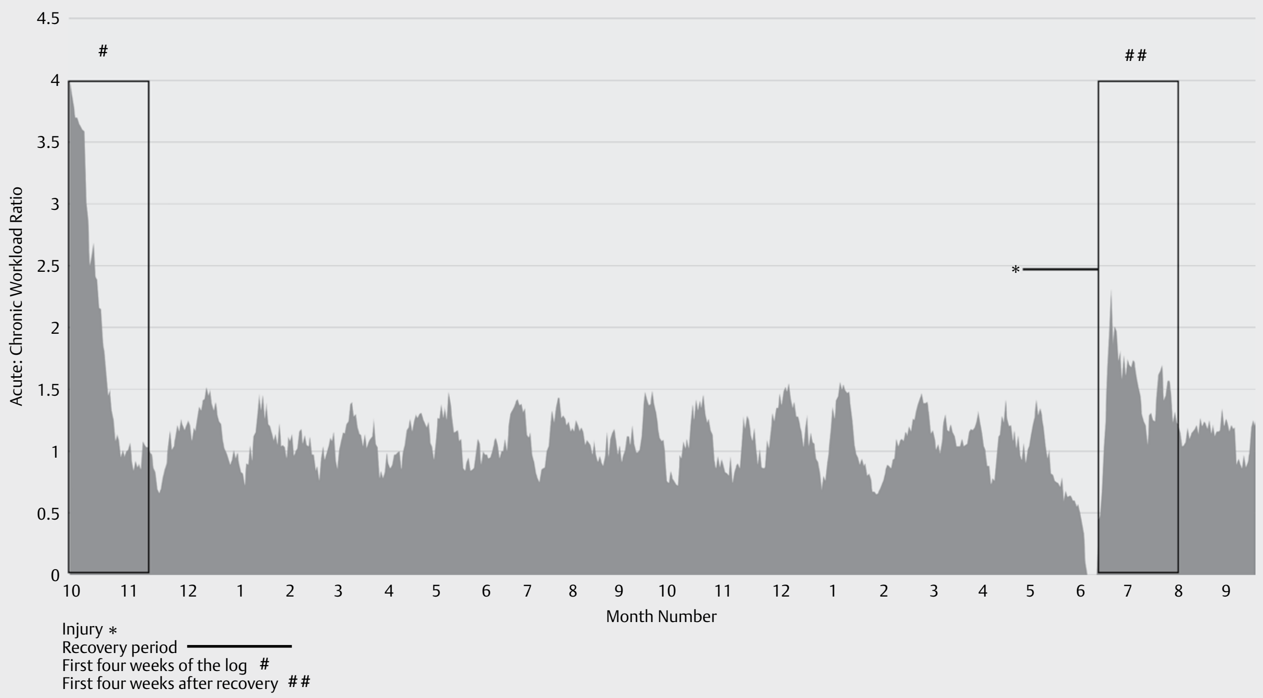
Definition of injury

An injury was defined as any musculoskeletal problem of the lower extremity or back that led to an inability to execute training or competition as planned for at least one week [25]. Only injuries sustained as a result of training or competition were considered. Recovery from an injury was defined as the ability to complete the normal training schedule. At the start of the study, the runners filled out a validated questionnaire on injury history based on Fuller et al. [26]. During the study period of 24 months, the runners kept a daily log on sustained injuries. The coach added information about the observed injuries to this log.

▶**Table 1** Baseline characteristics of the runners.

	Male	**Female**	**Total**
Number	16	7	23
Age (years; mean ± SD)	22.5 ± 6.3	21.4 ± 4.4	22.2 ± 5.7
Height (cm; mean ± SD)	185 ± 5	172 ± 7	181 ± 8
Body weight (kg; mean ± SD)	68.6 ± 6.0	58.3 ± 4.0	65.4 ± 7.2
Percentage body fat * (%; mean ± SD)	8.5 ± 2.3	17.6 ± 4.2	11.3 ± 5.2
VO_2max * * (ml/kg/min; mean ± SD)	66.7 ± 5.9	62.7 ± 7.4	65.5 ± 6.5

SD = Standard Deviation; cm = centimetre; kg = kilogram; ml = millilitre; min = minutes; VO_2max = Maximal measured oxygen uptake * The percentage body fat was estimated using the Tanita BC 418. * * The VO_2max was measured with a maximal incremental treadmill test including breath-by-breath gas analysis using the Cortex Metalyzer 3 B.



▶ **Fig. 1** Visualisation of a runners 24 months ACWR containing an injury and corresponding recovery period, with an biased ACWR due to a biased chronic workload ratio in the first four weeks of the log and four weeks after a recovery period.

Quantifying workloads

The coach developed a training and competition schedule for each runner and recorded the ability of the individual runner to execute the planned schedule. Each individual runner filled out their daily training and competition schedule for duration and intensity of all training sessions and running competition events. The training sessions consisted of various types of training, for example endurance training, technique training, and strength training. The duration of the training and competition sessions was reported in minutes.

In addition, the intensity was determined by the rating of perceived exertion per session (sRPE), which was reported by the runners approximately 30 minutes after each session on the Borg Scale ranging from 6 to 20 [27].

The workload of each training session and competition event was calculated by multiplying the sRPE scores with the duration and was expressed in arbitrary units (AU).

Data analysis

Data of one runner was removed from the data set for not adequately recording duration and intensity. The remaining data on workload were divided into weekly blocks from Monday to Sunday. The weekly blocks represent the acute workload. The chronic workload was calculated as the four week rolling average of the acute workload [9, 11, 12, 19, 28]. The ACWR was determined dividing the acute workload by the chronic workload (the coupled approach), indicating the relative size of acute workload compared to the chronic workload [9, 11, 12, 19, 28]. An ACWR below one represents an acute workload that is lower than the chronic workload. Conversely, an ACWR value above one represents an acute workload, which is higher than the chronic workload.

The first four weeks of the study, the weeks in which runners were injured, as well as the four weeks after recovery from the injury were removed from the analysis of the ACWR and the chronic workload [12]. It is only after four weeks of normal workload that the chronic workload represents a non-biased value with respect to the injury occurrence [12]

Removing the weeks in which runners were injured created a separation between the load calculation window and the injury risk window [29, 30]. Subsequently the injury lag period was generalized to a risk window of a seven days period. ▶ **Figure 1** shows a visualization of a runners' ACWR for the 24 months, a sustained injury and the corresponding recovery period to illustrate the influence of a very low chronic workload on the ACWR. The normality of the distribution of the acute workload, the chronic workload, the ACWR and differences between the ACWR were tested. For all statistical analysis, we used IBM SPSS 2.4, unless indicated otherwise.

The z-score for the acute workload, the chronic workload and the weekly ACWR of the individual runners were calculated to indicate whether the observed value was above or below the average for the individual. The acute workload, chronic workload and the ACWR were classified accordingly [11, 12]. The classifications consisted of the following week categories: (i) Very low, (ii) Low (iii) Moderate low, (iv) Moderate high, (v) High, (vi) Very high. The thresholds of categories based on the corresponding the z-scores are presented in ▶ **Table 2**.

▶ **Table 2** Workload classifications and boundaries.

Workload category	**z-Score**	**Acute Workload AU**	**Chronic Workload AU**	**Weekly ACWR ratio**
Very low	≤ −2.00	≤ 3810	≤ 6297	≤ 0.24
Low	−1.99 – − 1.00	3811–8170	6298–9158	0.25–0.68
Moderate Low	− 0.99 – − 0.01	8171–10 880	9159–10 832	0.69–1.10
Moderate High	0.00–0.99	10 881–14 998	10 833–13 485	1.11–1.53
High	1.00–1.99	14 999–18 052	13 486–19 675	1.54–1.96
Very High	≥ 2.00	≥ 18053	≥ 19 676	≥ 1.96
Workload difference category	**z-Score**	**Week-to-week ACWR difference**	**Fortnightly ACWR difference**	
High decrease	≤ −2.00	≤ −0.57	≤ −0.53	
Moderate	−1.99 – −1.00	−0.56 – −0.24	−0.54 – −0.27	
decrease	−0.99 – −0.01	−0.25–0.05	−0.27–0.10	
Low decrease	0.00–0.99	0.05–0.62	0.10–0.78	
Low increase	1.00–1.99	0.63–1.14	0.79–1.29	
Moderate increase	≥ 2.00	≥ 1.15	≥ 1.30	
High increase				

AU = Arbitrary Units. ACWR = Acute:Chronic Workload Ratio.

The week-to-week ACWR difference is the difference of the ACWR between two subsequent weeks. The fortnightly ACWR difference is the difference between the average of the ACWR of two subsequent weeks compared with average of the ACWR of the following two subsequent weeks. The week-to-week and fortnightly ACWR difference were categorized in the following week-to-week and fortnightly AWCR difference categories: (i) High decrease, (ii) Moderate decrease, (iii) Low decrease, (iv) Low increase, (v) Moderate increase, (vi) High increase [11, 12]. The thresholds of the weekly and fortnightly difference categories were based on the distribution of the z-scores. The weekly and fortnightly difference categories and the corresponding thresholds are presented in ▶ **Table 2**.

Determining association

The association between workload and injury risk was determined for the workload categories related to the four week blocks preceding the injury. The risk of sustaining an injury was calculated using a binary logistic regression model that modelled acute workload week categories, chronic workload week categories, the ACWR week categories, the week-to-week and fortnightly ACWR difference categories as independent variables and injury/no injury as dependent variable. The 'Low' week category and the 'Low decrease' ACWR difference category were the reference categories. The data were statistically analysed using R version 3.4.4 (R Foundation for Statistical Computing, Vienna, Austria) and the caret library, version 6.0.79.

Determining relative risk and prediction

For the workload variables and the affiliated categories, which showed a significant association ($P < 0.05$), the metrics for relative risk and prediction were calculated. A two-by-two table was used to determine basics for the metrics [31]. The two-by-two table consists of four categories: (i) True Positive (TP; i. e., the support for the identified associated categories in relation with the injury incidence), (ii) True Negative (TN; i. e., the support for the non-associated categories and the non-injury incidence), (iii) False Positive (FP; i. e., the support for the identified associated categories which did not result in an injury), and (iv) False Negative (FN; i. e., the support for the non-associated categories which resulted into an injury). The metrics for injury occurrence were the relative risk (RR), the standard error (SE) of log RR, the 95 % confidence interval (CI 95 %), and the p-value of the relative risk. The RR, its SE, the CI 95 % and p-value were calculated accordingly [31, 32]. The predictive power of the significant workload variables and the affiliated categories were calculated by the sensitivity and specificity [33].

The relative risk was calculated as

$$\mathrm{RR} = \frac{\mathrm{TP}/(\mathrm{TP}+\mathrm{FP})}{\mathrm{FN}/(\mathrm{FN}+\mathrm{TP})}$$

for which the SE of the log of the RR can be calculated as

$$\mathrm{SE}\{\ln(\mathrm{RR})\} = \sqrt{\frac{1}{\mathrm{TP}} + \frac{1}{\mathrm{FN}} - \frac{1}{\mathrm{TP}+\mathrm{FP}} - \frac{1}{\mathrm{TN}+\mathrm{TP}}}$$

When a category caused a division by zero in calculation of the RR or the SE, 0.5 was added to all four categories of the two-by-two table [3].

We calculated the 95 % CI as $\ln\ln(\mathrm{RR}) \pm 1.96^{*}\,\mathrm{SE}\{\ln\ln\mathrm{RR}\}$. We determined the p-value with the calculated z-value, [z-value = lnln(RR)/SE{lnln(RR)}]. Finally, we calculated the sensitivity and specificity. The sensitivity was calculated as the proportion of correctly identified injuries, as sensitivity = [TP/TP + FN]. The specificity was calculated as the proportion of correctly identified non-injuries, as specificity = [TN/TN + FP]. The calculations were performed using Microsoft Excel 2016.

We confirm the study meets the ethical standards of the International Journal of Sports Medicine [34].

▶**Table 3** Descriptive statistics for all runners' workload variables.

Workload	**Weeks preceding an injury**					**Weeks without an injury**	**Difference between average pre-injury and non-injury**
	Week –4	**Week –3**	**Week –2**	**Week –1**	**Average**	**Average**	**p-value**
Chronic	6401 ± 2301	7378 ± 2685	7050 ± 2382	6850 ± 2360	6920 ± 2433	6772 ± 3195	0.502
Acute	7238 ± 3291	7014 ± 3228	8099 ± 3986	7163 ± 2778	7379 ± 3321	6791 ± 3695	0.484
Acute:chronic	0.99 ± 0.32	1.05 ± 0.35	1.12 ± 0.35	1.15 ± 0.19	1.08 ± 0.30	1.11 ± 0.44	0.601

All data are mean ± Standard Deviation.

▶**Table 4** Frequency workload classifications and boundaries.

Workload category	**z-Score**	**Acute Workload AU**	**Chronic Workload AU**	**Weekly ACWR ratio**
Very low	≤ –2.00	0	43	59
Low	− 1.99 – −1.00	193	171	77
Moderate Low	− 0.99 – −0.01	589	556	621
Moderate High	0.00–0.99	533	541	734
High	1.00–1.99	173	181	19
Very High	≥ 2.00	42	38	20
Workload difference category	**z-Score**	**Week-to-week ACWR difference**	**Fortnightly ACWR difference**	
High decrease	≤ –2.00	22	40	
Moderate	–1.99 – −1.00	55	78	
decrease	–0.99 – −0.01	623	578	
Low decrease	0.00–0.99	761	714	
Low increase	1.00–1.99	61	98	
Moderate increase	≥ 2.00	8	22	
High increase				

AU = Arbitrary Units. ACWR = Acute:Chronic Workload Ratio.

Results

Workload

The 22 runners conducted 13 046 training sessions with a total number of 20 139 training hours. The average weekly training hours were 8.9 ± 4.6 and the average duration of a training session was 77.6 ± 39.3 minutes. The session RPE was 12.3 ± 3.1 on the Borg scale, the workload per session was 1031 ± 661 AU, the daily workload was 1241 ± 815 AU. The acute workload per week was 6801 ± 3675 AU, the chronic workload per week was 6750 ± 3185 and the overall corresponding ACWR was 0.99 ± 0.47. The descriptive statistics for the 22 runners' workload variables split between the weeks preceding the inury and the weeks not preceding an injury are presented in ▶**Table 3**.

Excluding the first four weeks of the study, the weeks in which runners were injured, and the four weeks after recovery from the injury, reduced the number of training weeks by 25.9 %, i. e. from 2066 to 1530 weeks of the data set. The frequency distribution of the variables are to be found in ▶**Table 4**.

Injuries

During the 24 months, 21 runners sustained one or more injuries (▶**Table 5**). Initially, 57 injuries were identified with an average injury rate of 3.6/1000 h. Four injuries skewed the mean recovery time, accounting for 1002 recovery days out of 3247 recovery days.

Association

There were no associations (P < 0.05) between the acute workload, the chronic workload or the weekly ACWR and the injury risk. However, two ACWR difference categories showed significant associations with the injury risk: (i) the fortnightly ACWR difference category 'Low increase' (p < 0.001) and (ii) the week-to-week ACWR difference category 'Low increase' between week three and two before an injury (p = 0.013) (▶**Table 6**).

Relative risk and prediction

Fortnightly and between weeks three and two before an injury the ACWR difference category 'Low increase' was associated with the risk on sustaining an injury. The runners sustaining an injury with the fortnightly ACWR difference category 'Low increase' had a RR of injury of 4.49 (CI 95 %: 2.02–9.96, p < 0.000). The relative risk for sustaining an injury with the week-to-week ACWR difference category 'Low increase' between week three and two was 2.74 (CI 95 %: 1.30–5.76, p = 0.012). In terms of percentage, the ACWR difference category 'Low increase' is overrepresented in the four-week period before

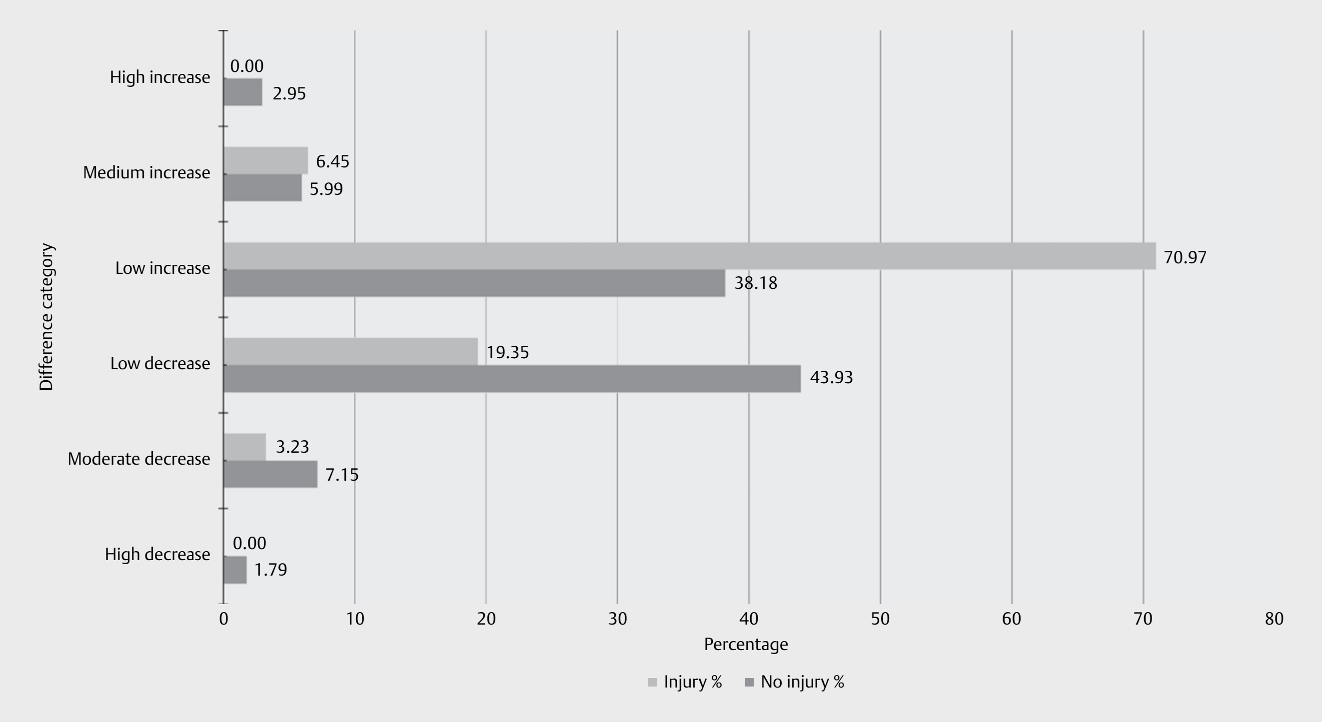
▶**Table 5** Overview of the injuries.

Injuries	Male	Female	Total
Runners with no injuries (Frequency)	1	0	1
Runners with one injury (Frequency)	2	2	4
Runners with two injuries (Frequency)	5	2	7
Runners with three injuries (Frequency)	3	0	3
Runners with four injuries (Frequency)	4	2	6
Runners with five injuries (Frequency)	0	0	0
Runners with six injuries (Frequency)	1	0	1
Injury location (back/hip/knee/calf-Achilles/ankle-foot) (Frequency)	3/5/9/17/7	2/1/0/7/7	5/6/9/24/14
Time to recovery (days; median(range))	48 (7–201)	77 (9–306)	56 (7–306)

▶**Table 6** Binary logistic regression on difference categories of the Acute:Chronic Workload Ratio before the injury.

Difference categories (reference difference category Low decrease)				
	p-value			
	Week –3–4	**Week –2–3**	**Week –1–2**	**Fortnightly: week –12–34**
High decrease	0.992	0.987	0.451	0.988
Moderate decrease	0.791	0.682	0.897	0.257
Low increase	0.125	0.013 *	0.877	0.001 *
Moderate increase	0.791	0.494	0.897	0.174
High increase	0.990	0.991	0.989	0.991

* Significant difference ($p<0.05$) between the periods preceding an injury and the periods not preceding an injury.



▶**Fig. 2** Distribution of the difference categories of the fortnightly ACWR, comparing the period before the injury with the remaining weeks without resulting in an injury.

the injury in comparison with the periods not preceding an injury. ▶**Figure 2** illustrates the distribution of the fortnightly AWCR difference categories comparing the period before the injury with the period without injuries.

The predictability of an injury expressed by the specificity and sensitivity is limited. The fortnightly AWCR difference category ‘Low increase’ has specificity of 0.62 and a sensitivity of 0.74.

Where the AWCR difference category 'Low increase' between week two and three has a specificity of 0.57 and a sensitivity of 0.68.

Discussion

The current study expressed the workload in running as the combination of duration and RPE and investigated the association between the acute workload, the chronic workload, the ACWR, the change in the ACWR and the injury risk in competitive runners. We did not find an association between the acute workload, the chronic workload, the ACWR and injury risk. However, a 4.5-fold increase in injury risk was associated with low increase (0.10–0.78) of the fortnightly AWCR difference. Also, a 2.7-fold increase in injury risk was demonstrated for a low increase (0.05–0.62) of the week-to-week ACWR difference between week three and two before an injury. These findings suggest that there is an association between increased ACWR and the risk of sustaining an injury.

The injury incidence of 3.6/1000 h was comparable to previous studies on competitive runners that found incidences from 2.5–7.4 injuries per 1000 h for long-distance runners [35, 36] and 5.6–5.8 for sprinters and middle-distance runners [36]. Conform literature most injuries in the current study were reported in the calf-Achilles region [23, 27].

A main difference between the literature on running and injury risk and this study is the definition of workload. Previous studies in running defined workload as a single nonrelative factor, like duration, distance or frequency [4, 6, 7], whereas we applied a combination of duration and RPE, the sRPE [23]. The sRPE was expressed in acute and chronic workload. The current research did not show an association between acute or chronic workload and injury risk. Based on the literature on running one cannot draw a conclusion on the relationship between a single nonrelative workload factor and injuries risk [4, 6, 7]. The reason for not identifying a relationship in both literature and our study might be found in the employed method of using a nonrelative factor. This emphasizes the importance of including relative measures to a runner's individual training progression. Therefore, this study also used a relative measure (ACWR). The ACWR as a single factor was not associated with injury risk although other studies showed that spikes in the acute workload, is associated with an increase in injury risk in Australian football [9], rugby [11] and cricket [12]. Contrary to these studies, there were relatively few spikes in the current training data set. In other words, the competitive runners in this study were not regularly exposed to a high increase of acute workloads. Absence of spikes in our dataset does not rule out that there is an association, but we were not able to study this phenomenon when using the acute workload and the related ACWR.

In contrast with previous studies in competitive running using average load to identify injury risk, the present study was the first to take the change in the relative workload into account. The study demonstrated an association between an increase in the fortnightly and week-to-week ACWR difference and injury risk. This is consistent with the studies in Australian football, rugby, cricket, and soccer [9–13, 19, 37].

A notable finding is the delay of two weeks between the increase of the fortnightly and week-to-week ACWR difference and the injury manifestation. A similar observation was made in cricket and Australian football [9, 12]. Those studies showed an increase in injuries the subsequent week after a high increase of workload. A possible explanation for the difference in delay is the occurrence of spikes in the week before the injury in their study whereas in our study a more cumulative overloading took place.

Although an increased risk of sustaining an injury was found, the predictive value of the increase of the fortnightly and week-to-week ACWR difference is low.

The fortnightly AWCR difference category 'Low increase' had a specificity of 0.62 and a sensitivity of 0.74. The week-to-week AWCR difference category 'Low increase' between week three and two before an injury had a specificity of 0.57 and a sensitivity of 0.68.The low specificity and low sensitivity illustrates that the 'Low increase' of the fortnightly and week-to-week AWCR difference, though an important signal for an increase in injury risk, is insufficient as a single predictor of an injury. This is consistent with Carey et al. [29] and Fanchini et al. [37] where objective, subjective and relative measures proved to have poor ability to predict an injury.

Another limitation of the study is the calculation of the ACWR. The ACWR is only an unbiased measure after 28 days of completing a normal training schedule. Therefore, the first four weeks of data at the start of the running season, the first four weeks of data after recovery, and the data of the rehabilitation period could not be used for monitoring ACWR. The removal of the first four weeks of data of the running season prevented studying possible influences of the start of a season. Another limitation is the removal of the first four weeks after recovery along with the removal of the rehabilitation period. This removal eliminated the possibility to study the influence of the possible workload difference between rehabilitation training and regular training. Although when the ACWR is looked at in an elite training setting, the assessment of the ACWR during recovery can be an indicator whether an athlete is prepared well enough to enter a normal training schedule [38].

From our study, we conclude that the ACWR is a useful measure to identify an increased injury risk in competitive running. The ACWR could be taken into account when designing training schedules, observing the ability to execute the planned training schedule and monitoring the ACWR recorded by the runner. Timely identification of an increase of the ACWR may enable timely preventive measures decreasing the injury risk in runners.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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