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Journal article

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Murray, Nicholas, Gabbett, Tim and Townshend, Andrew

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Authors: Nick B. Murray ^a, Tim J. Gabbett ^{b, c}, Andrew D. Townshend ^a

Affiliations: ^a School of Exercise Science, Australian Catholic University, Brisbane, Queensland, Australia. ^b Gabbett Performance Solutions, Brisbane, Queensland, Australia. ^c Institute for Resilient Regions, University of Southern Queensland, Ipswich, Queensland, Australia.

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RUNNING HEAD: Relative loads in Australian football

The use of relative speed zones in Australian Football: Are we really measuring what we think we are?

Nick B. Murray ^a, Tim J. Gabbett ^{b, c}, Andrew D. Townshend ^a

^a *School of Exercise Science, Australian Catholic University, Brisbane, Queensland, Australia*

^b *Gabbett Performance Solutions, Brisbane, Queensland, Australia*

^c *Institute for Resilient Regions, University of Southern Queensland, Ipswich, Queensland, Australia*

Address correspondence to:

Mr. Nick B. Murray
School of Exercise Science,
Australian Catholic University,
Brisbane, AUSTRALIA, 4014
Email: nicholas.murray@myacu.edu.au

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Abstract

Objectives: This study aimed to examine the difference between absolute and relative workloads, injury likelihood, and the acute:chronic workload ratio (ACWR) in elite Australian football. **Design:** Single cohort, observational study. **Methods:** Forty-five elite Australian football players from one club participated in this study. Running workloads of players were tracked using Global Positioning System technology, and were categorised using either; (1) absolute, pre-defined speed thresholds, or (2) relative, individualised speed thresholds. Players were divided into three equal groups based on maximum velocity; (1) faster, (2) moderate, or (3) slower. One-week and four-week workloads were calculated, along with the ACWR. Injuries were recorded if they were non-contact in nature and resulted in “time-loss”. **Results:** Faster players demonstrated a significant overestimation of very high-speed running when compared to their relative thresholds ($p=0.01$, $ES=-0.73$). Similarly, slower players demonstrated an underestimation of high- ($p=0.06$, $ES=0.55$) and very high-speed ($p=0.01$, $ES=1.16$) running when compared to their relative thresholds. For slower players, (1) greater amounts of relative very high-speed running had a greater risk of injury than less ($RR=8.30$, $p=0.04$), and (2) greater absolute high-speed chronic workloads demonstrated an increase in injury likelihood ($RR=2.28$, $p=0.16$), while greater relative high-speed chronic workloads offered a decrease in injury likelihood ($RR=0.33$, $p=0.11$). Faster players with a very high-speed ACWR of >2.0 had a greater risk of injury than those between 0.49-0.99 for both absolute ($RR=10.31$, $p=0.09$) and relative ($RR=4.28$, $p=0.13$) workloads. **Conclusions:** The individualisation of velocity thresholds significantly alters the amount of very high-speed running performed and should be considered in the prescription of training load.

KEY WORDS: GPS; Training; Physical Performance; Sport

Introduction

Australian Football (AF) is a fast-paced, highly intermittent sport requiring players to perform high-intensity activities (i.e. sprinting, running, and physical contacts) interspersed with low-speed (i.e. walking and jogging) movements.^{1,2} It is common practice in elite sporting organisations to use Global Positioning System (GPS) technology to provide information on the activity profiles of players during training and competition.³⁻⁵ With the physical demands of AF increasing,⁶ it is critical that strength and conditioning staff prescribe an appropriate training stimulus to enhance the individual physical qualities of players in their squads.

While activity profiles have been extensively researched,^{1,3,7} a common methodological limitation is the sole use of absolute, pre-defined speed thresholds rather than thresholds that are calculated relative to an individual's capacity.⁸ It has been proposed that faster players may perform at a relatively lower percentage of their maximum capacity when compared with slower players who may perform at a relatively higher percentage of their maximum capacity.⁹ If a discrepancy exists between absolute and relative quantification of workload, this has significant implications when planning individualised training programs, accurately quantifying an individual's training load, and the relative stress and recovery status of the player.⁸ In junior rugby league players, it was reported that match intensity increased as age increased if data were reported according to pre-defined absolute thresholds, however when expressed relative to individual sprinting capacity, younger players exhibited higher playing intensities and performed greater amounts of high-speed running (HSR).⁹ Similarly in comparison to a standardised HSR threshold of $5 \text{ m}\cdot\text{s}^{-1}$, using a relative HSR threshold of 60% of maximum velocity resulted in a significant underestimation of HSR in professional rugby union forwards, and a significant overestimation of HSR in the backs positional group.⁸ Further, in work conducted during professional soccer match-play,¹⁰ there were significant differences in high-intensity distance run when a relative HSR threshold was used – rather than

an absolute speed threshold.¹⁰ Abt and Lovell¹⁰ found that high-speed running was substantially underestimated when using a pre-defined absolute high-speed running threshold of 19.8 km.hr⁻¹. Collectively, these findings suggest that the sole use of an arbitrary, absolute, pre-defined speed threshold may under- or over-estimate the true physical demands of training and competition.

In AF the session rating of perceived exertion (RPE)¹¹ and GPS-derived running loads¹² have been used to compare injury risk with absolute workloads (i.e. 1-week, or 3-week), or previous-to-current week changes in load. In recent injury investigations in cricket,¹³ rugby league,^{14,15} Gaelic football,¹⁶ Australian football,^{17,18} and elite youth football,¹⁹ the acute:chronic workload ratio (ACWR) has been used to compare the acute workload (i.e. workload performed in one week), with the chronic workload (i.e. rolling 4-week average workload) as a ratio to give a representation of a player’s “preparedness” to train or play.²⁰ There are two general findings across these sports; 1) higher chronic workloads may offer a protective mechanism against injury, and 2) large spikes in workload, reflected by a very high acute:chronic workload ratio (i.e. >2.0), are associated with an increased risk of injury in both the current^{14,15,17} and subsequent week.^{13,15,17} Specifically in AF, using absolute velocity thresholds, sharp increases in high-speed running load (i.e. ACWR >2.0) have been associated with an increased risk of injury using both a rolling averages model (RR=11.62, $P=0.006$),¹⁷ and more recently an exponentially weighted moving averages (EWMA) model (RR=4.66, $P=0.004$).¹⁸ Although these findings are significant, we are currently unaware of the relationship between relative running loads and injury risk in elite AF players.

To date, no research has investigated the differences in absolute and relative external workloads through the use of relative speed thresholds in elite AF. Therefore, the aim of the present study was to investigate the differences in activity profiles when data are expressed as both an absolute threshold, and relative to the individual player’s maximum velocity. A second

aim was to examine if the use of relative acute and chronic running workloads, and the acute:chronic workload ratio were associated with subsequent injury risk in elite Australian footballers.

Methods

Participants

Forty-five elite AF players from one club (mean \pm SD age, 22 ± 3 years; height, 190 ± 7 cm; mass, 89 ± 8 kg) participated in this study. Data were collected over the course of one Australian Football League (AFL) season consisting of a 16-week pre-season period which included running and football-based sessions, and a subsequent 23-week in-season competitive period. All participants received a clear explanation of the study, including detailed information on the risks and benefits of participation and provided written informed consent. The Australian Catholic University Human Research Ethics Committee approved all experimental procedures (Approval Number 2016-40E).

Monitoring Workloads

Data were collected using GPS technology sampling at 10 Hz (Optimeye S5, Catapult Innovations, Melbourne, Victoria, Australia), which provided information on the movement demands of players across the season. The GPS unit also housed a tri-axial accelerometer, gyroscope, and magnetometer sampling at 100 Hz. This technology has demonstrated acceptable validity and reliability when measuring velocity, distance, and accelerations in both laboratory- and field-based testing.^{21,22} Further, when compared with earlier models (i.e. 1 Hz and 5 Hz), 10 Hz GPS units are the most valid and reliable within both linear, change of direction, and team sport simulated testing conditions to provide information on the physical movement demands of training and match-play.^{23,24} Maximum velocity was tracked across the season using GPS technology, as no significant differences have been found for speed measures

assessed using timing gates and GPS devices in a cohort of team sport players.²⁵ Each player wore the same unit for each session, and data were analysed using the same software for the duration of the study (Catapult Openfield v1.13.1, Catapult Innovations, Melbourne, Victoria, Australia).²⁵ Absolute workload data were expressed as the total running distance players completed at low ($<6 \text{ km}\cdot\text{hr}^{-1}$), moderate ($6\text{--}18 \text{ km}\cdot\text{hr}^{-1}$), high ($18\text{--}24 \text{ km}\cdot\text{hr}^{-1}$), and very high ($>24 \text{ km}\cdot\text{hr}^{-1}$) speeds as both absolute pre-defined speed zones, and relative to the individual player's maximum velocity. The maximum velocity of each participant was determined at the beginning of the season. If a player achieved a higher maximum velocity in training (which included dedicated speed training sessions) or competition, this then became their new maximum velocity for the remainder of the data collection period.

Calculating Relative Workloads

In order to calculate a player's individual thresholds, the average maximum velocity ($32.1 \text{ km}\cdot\text{hr}^{-1}$) was used as a reference to create the relative thresholds for each speed zone. Each relative zone was calculated as a percentage of the absolute thresholds defined above and then rounded to enhance the practical application of the data. The relative thresholds that were applied, based on an individual's maximum velocity, were; low (0-19.99%), moderate (20-54.99%), high (55-74.99%), and very high ($>75\%$). These relative zones closely reflected the absolute zones of; low ($<6 \text{ km}\cdot\text{hr}^{-1}$), moderate ($6\text{--}18 \text{ km}\cdot\text{hr}^{-1}$), high ($18\text{--}24 \text{ km}\cdot\text{hr}^{-1}$), and very high ($>24 \text{ km}\cdot\text{hr}^{-1}$), and were chosen to closely replicate relative high-speed running thresholds used previously.^{8,9} To assess the differences between absolute and relative workloads, players were divided equally into thirds to either a (i) faster (maximum velocity $>32.70 \text{ km}\cdot\text{hr}^{-1}$, $n = 15$), (ii) moderate (maximum velocity $31.70\text{--}32.69 \text{ km}\cdot\text{hr}^{-1}$, $n = 15$) or (iii) slower (maximum velocity $<31.69 \text{ km}\cdot\text{hr}^{-1}$, $n = 15$) group based on the maximum velocity reached across the season.

Acute and chronic workload were calculated as rolling averages using 7- and 28-days respectively as described by Hulin et al.¹³ and the EWMA acute:chronic workload ratio data were calculated using the methods described by Murray et al.¹⁸ Workload variables were divided into logical increments to enhance the application of the findings to the real-world. The chosen increments were the same across both acute and chronic workload variables. The EWMA 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, 1.50-1.99, and (e) very high, ≥ 2.0 . An injury was defined as any non-contact “time-loss” injury obtained during training or competition that resulted in a missed training session or game.^{11,17} Medical staff at the football club classified all injuries and updated relevant injury databases throughout the season. Injury likelihoods were calculated based on the total number of injuries sustained, relative to the total number of players exposed to each given workload category. Injury likelihoods and risks (RR) for both the current week, and subsequent week were calculated.²⁶

Statistical Analysis

Data were analysed using SPSS 24.0 (SPSS Inc., Chicago, IL, USA). Distance covered in each of the absolute and relative zones were compared using multiple one-way analyses of variance (ANOVA) to determine if there were significant differences between conditions (i.e. absolute and relative). The GPS data was log-transformed to provide the coefficient of variation (CV), which is the variation of performance expressed as a percentage of the average performance. Further, the between-subject standard deviation was calculated and expressed as a percentage. The between-subject standard deviation was multiplied by 0.2 to determine the smallest worthwhile change (SWC) for each variable. The minimum criterion change required to produce a probable significant change in performance was calculated as previously described.^{27,28} The likelihood of sustaining an injury was analysed using two binary logistic

regression models with significance set at $P < 0.05$. Acute and chronic workloads, and the acute:chronic workload ratio were independently modelled as predictor variables (for both absolute and relative thresholds), and injury/no injury as the dependent variable. The very high acute:chronic workload ratio (i.e. >2.0) group was used as the reference group to which each other group was compared. Given the real-world practical nature of the study, magnitude-based inferences were used to determine the Cohen’s Effect Size (ES) statistic and 90% confidence intervals (CI).²⁷ Effect sizes of <0.2 , $0.21–0.60$, $0.61–1.20$, and >1.20 were considered trivial, small, moderate, and large, respectively.²⁷ Likelihoods were subsequently generated and thresholds for assigning qualitative terms to chances assigned. The magnitude of differences between groups were considered practically meaningful when the likelihood was $\geq 75\%$.^{28,29}

Results

Absolute and relative weekly average workload for the duration of the study is presented in Table 1. Moderate-speed distance was significantly lower when quantified using relative workload than absolute workload ($p=0.03$, $ES=-0.45$ (90% CI $-0.80–0.11$), 89% Likely). No other significant differences were found between absolute and relative weekly average workload for the group. The variability of the measured variables across the season are presented in Table 1. The actual percentage difference in absolute and relative workloads for high-speed distance (in slower players) and very high-speed distance (in slower and faster players) was greater than the minimum criterion change required to produce a probable significant difference in performance.

Multiple significant relationships were found for high, and very-high speed distance when data were expressed as either absolute or relative speeds. Specifically, faster players experienced a significant overestimation of very high-speed running when absolute workload thresholds were used compared with the use of relative workload thresholds ($p=0.02$, $ES=-0.81$

(90% CI -1.38--0.23), 96% Very Likely). In addition, faster players performed relatively greater low-speed running when compared with the absolute workload threshold ($p=0.13$, $ES=0.56$ (90% CI -0.04–1.17), 84% Likely). In contrast, slower players performed relatively less moderate-speed running when the relative workload thresholds were applied ($p=0.13$, $ES=-0.56$ (90% CI -1.16–0.05), 84% Likely). Further, slower players experienced a practically meaningful underestimation of high-speed ($p=0.07$, $ES=0.66$ (90% CI 0.06–1.25), 90% Likely) and very high-speed ($p=0.01$, $ES=1.40$ (90% CI 0.95–1.85), 99% Almost Certainly) running, respectively, when using a relative workload threshold compared with an absolute workload threshold (Figure 1) (Table 1).

Over the duration of the study, 31 injuries were recorded. The most common site of injury was the hamstring (29%), followed by the groin/hip flexor (25%), and calf (13%). Using absolute workloads, faster players with an acute high-speed distance workload of >3000 m had a greater risk of injury compared to those with a high-speed distance workload of <2000 m ($RR=4.26$, 90% CI 1.64 to 11.04, $p=0.06$, 96.2% Very Likely) and 2500 – 3000 m ($RR=3.96$, 90% CI 0.26 to 60.60, $p=0.19$, 88.9% Likely). Similarly when relative workloads were applied, faster players with an acute high-speed distance workload of >3000 m had a significantly greater risk of injury than those who completed <2000 m ($RR=4.82$, 90% CI 2.24 to 10.37, $p=0.04$, 97.2% Very Likely). In addition, slower players who completed >3000 m of absolute high-speed distance in an acute period had an increased risk of injury compared with those who completed both <2000 m of absolute ($RR=4.18$, 90% CI 1.21 to 14.46, $p=0.08$, 95.1% Very Likely), and relative ($RR=4.23$, 90% CI 0.30 to 60.54, $p=0.18$, 89.7% Likely) distance, and 2001-2500m of absolute ($RR=3.07$, 90% CI 0.08 to 48.11, $p=0.30$, 82.3% Likely) distance, respectively. Further, with the application of relative thresholds, slower players with an acute relative very high-speed distance >1500 m experienced a greater injury risk than those who completed <500 m ($RR=8.30$, 90% CI 3.02 to 22.77, $p=0.04$, 97.4% Very Likely), and 501-

1000 m (RR=4.53, 90% CI 0.24 to 85.16, p=0.19, 89.3% Likely), but not 1001-1500 m (Figure 2).

In regard to chronic workload for slower players, a higher absolute chronic workload (>3000 m) for high-speed distance was associated with an increased risk of injury when compared with a lower chronic workload of < 2000 m (RR=2.28, 90% CI 0.14 to 36.57, p=0.16, 80.9% Likely). However, a higher relative chronic workload (>3000 m) for high-speed distance was associated with a decreased injury risk for slower players when compared with a lower chronic workload of 2000-2500 m (RR=0.33, 90% CI 0.09 to 1.22, p=0.11, 93% Likely). There were no other significant differences in chronic workload for faster or slower players when absolute and relative thresholds were applied (Figure 3).

An ACWR of >2.0 for faster players using absolute workloads was associated with a significantly greater risk of injury than those with an ACWR of 0.49-0.99 for low- (RR=32.40, 90% CI 27.27 to 38.50, p=0.01, 99.7% Almost Certainly), moderate- (RR=21.12, 90% CI 8.26 to 53.99, p=0.03, 98.4% Very Likely), high- (RR=5.85, 90% CI 1.93 to 17.70, p=0.05, 96.5% Very Likely), and very high-speed (RR=10.31, 90% CI 0.98 to 58.85, p=0.10, 94.5% Likely) distance. Further, a greater ACWR (>2.0) for very high-speed distance was also associated with an increase in injury risk when compared with an ACWR of <0.49 (RR=4.77, 90% CI 0.07 to 69.85, p=0.25, 85.7% Likely). These findings were replicated when relative workloads were applied to faster players, where an ACWR of >2.0, when compared with 0.49 to 0.99, for low- (RR=32.65, 90% CI 28.43 to 37.49, p=0.01, 99.8% Almost Certainly), moderate- (RR=21.00, 90% CI 7.98 to 55.23, p=0.03, 98.3% Very Likely), high- (RR=5.52, 90% CI 2.49 to 12.16, p=0.04, 97.4% Very Likely), and very high-speed (RR=4.28, 90% CI 0.13 to 139.73, p=0.13, 87.0% Likely) distance resulted in a significant increase in injury risk. No significant findings were found for slower players using either absolute or relative workloads due to no injuries occurring in the reference group range of >2.0 (Figure 4).

Discussion

The present study investigated the weekly running demands of elite Australian football players using both absolute (i.e. pre-defined) and relative (i.e. relative to a players' individual maximum velocity) speed thresholds. Consistent with previous findings,^{8,9} we found when using relative speed thresholds slower players completed significantly greater amounts of high- and very high-speed running, whereas faster players completed significantly less very high-speed running compared with the use of absolute thresholds.. Further, we found that slower players who performed greater amounts of acute relative very high-speed running demonstrated a greater risk of injury than those who completed less relative very high-speed running. Additionally, we found that a higher absolute chronic workload for high-speed distance for slower players resulted in a practical increase in injury likelihood, while a higher relative chronic high-speed distance for slower players offered a practically decreased likelihood of injury. Finally, we also found that spikes in workload, resulting in an ACWR of >2.0 , were associated with a significant rise in injury likelihood for faster players, but not slower players.

The present study is the first to examine the application of absolute and relative thresholds in elite Australian football; although not the first in team sport.⁸⁻¹⁰ Our findings demonstrate that significant differences in very high-speed running exist when data are expressed relative to an individual's capacity. Specifically, when applying a relative threshold to slower players, their amount of very-high speed running is significantly increased. The opposite effect occurs in faster players, where a relative threshold significantly decreases their amount of very high-speed running. The use of absolute speed thresholds is important to allow the comparison of players' performance across positional groups during training and match-play.⁸ However, this method fails to account for individual variation, particularly in maximum velocity, across a playing group when considering the same absolute workload. Gabbett⁹ suggested that two players who completed the same absolute amount of very high-speed

running would result in a significantly greater strain on the player with a slower maximum velocity. This finding highlights the need to consider both absolute and relative demands of training and competition to prescribe an adequate training stimulus at an individual player level.^{8,9}

A key finding was the difference in injury likelihood in acute very high-speed distance for slower players when data were expressed using a relative threshold. While no difference was found when using absolute workloads, the relative risk of injury was 8.3 and 4.5 times greater when a slower player completed >1500 m of relative very high-speed running compared with <500 m and 501-1000 m, respectively. The implications of this finding are two-fold; 1) slower players fail to reach high amounts of absolute very high-speed distance, with no injuries occurring at the highest ranges with only minimal exposure, and 2) when an individual threshold is applied and slower players complete large amounts of very high-speed running in an acute 7-day window, their risk of injury significantly increases.

Further, we found that a higher absolute chronic high-speed workload for slower players practically increased their risk of injury, however a higher relative chronic high-speed workload for slower players offered a practically decreased risk of injury. The notion that moderate-to-high chronic workloads may offer a protective effect against injury is not new, with a series of papers in multiple sports reporting similar findings,^{14,31} as well as specifically in AF.^{17,32} This finding suggests that slower players who complete greater amounts of absolute high-speed running may be performing above their high-speed running “threshold” which contributes to a higher injury risk, however when compared to their relative threshold it offers a protective effect. This highlights the need for individualisation of high-speed running thresholds to gain a true understanding of injury risk at an individual player level. Further, it demonstrates that, for slower players, gradual building of relative high-speed running loads may offer a protective effect against injury, as opposed to building absolute high-speed running

loads which may increase the likelihood of injury for this cohort of players. While this finding demonstrates the importance of understanding the relative stress placed on an individual, it is also important to note that demands of competition are absolute. That is, it is irrelevant how ‘relatively’ fast a player is moving in a game, the player with a greater absolute maximum velocity will move faster. To mitigate this we can (1) select players with greater maximum velocity, and (2) increase speed through an adequate and specific training program, typically during the pre-season period.

The use of the EWMA model for ACWR calculation has only recently been proposed in the scientific literature,¹⁸ although a rolling average ACWR model has been examined multiple times before.^{15,19,20} The findings of this study extend recent work in Australian football,^{17,18,32} rugby league,^{14,15} cricket,¹⁴ soccer,^{19,30} and Gaelic football,^{16,31} which have collectively reported that large spikes in workload, resulting in a very high ACWR, were associated with a significant increase in injury risk. When categorised by maximum velocity, we found that faster players exhibited a similar trend where a significant increase in injury likelihood at a very high ACWR range for each variable, both absolute and relative, was demonstrated. This supports the previously raised notion²⁰ that there is a clear workload threshold where injury risk rises rapidly. Interestingly, we found no significant relationships between the EWMA ACWR and injury risk in the cohort of slower players in the present study. A possible explanation for this finding is the number of injuries recorded in the reference group of ACWR >2.0 (n=0). While significant differences were exhibited in the amount of very high-speed running recorded when data were expressed using absolute or relative thresholds, these differences did not translate to differences in injury likelihood in slower players. A further explanation for this finding may be that slower players were more tolerant to changes in ACWR because the absolute force (i.e. absolute very high-speed running) placed on their body was less than faster players. We suggest that further work, with a larger sample size of injuries

should be considered before drawing definitive conclusions regarding differences in injury risk for faster or slower players.

While this study is one of the first to investigate the use of relative speed thresholds in elite sport, there are some limitations that should be considered. First, the findings of the present study may be limited to this particular group of players from one club competing in the Australian Football League (AFL). Second, there are currently no universally accepted and standardised speed zones for the use of GPS technology across a range of team sports. The absolute speed thresholds in the present study are consistent with some,^{17,18} but not all,^{9,10,12} reported studies in the literature. While the GPS units used in this study provide a valid measure of maximum velocity when compared with a radar gun, it should be noted that there is a small error associated with the measurement of this quality when using GPS (Typical Error of the Estimate = 1.87 [90% CI 1.65 to 2.18%]).²⁵ The cohort of elite Australian footballers in this investigation did not undertake routine maximum velocity testing; the use of GPS technology represented the most practical alternative to timing gates for testing this quality. However, it should be noted that all recommendations for the use of GPS monitoring of field-based athletes,²³⁻²⁵ were followed when assessing maximum velocity over time. Finally, in the present study, the actual difference in absolute and relative workloads for high- and very high-speed distance was greater than the minimum criterion change required to produce a probable significant difference in performance. However, given the large variability in AF activity profiles as the speed of movement increases, sport scientists should be cautious when interpreting very high-speed running data. Further studies comparing data across a number of teams and a broader group of subjects may decrease the “noise” in the measurement of these variables, while also providing further insight on the absolute and relative running demands of AF.

Practical Applications

The findings of the present study demonstrate differences in player workload, specifically in very high-speed running, when data are expressed using either absolute or relative thresholds. These findings are important for those involved in the physical preparation, development, and monitoring of Australian football players. Specifically, conditioning staff should consider both the absolute and relative demands of training and competition to provide a comprehensive assessment of workload performed by a given player. By doing so, conditioning staff can prescribe an appropriate individualised training stimulus, in order to elicit a positive physiological response whilst minimising the risk of injury and negative responses associated with training. Further, large spikes in workload resulting in a very high ACWR (i.e. >2.0) for both absolute and relative thresholds, were significantly associated with an increased risk of injury in this cohort of Australian football players.

Conclusions

This is the first study to examine the differences between absolute and relative thresholds in elite Australian football players. Our findings demonstrate that, 1) differences in very high-speed running exist when data are expressed as either absolute or relative speed thresholds for faster and slower players, 2) large spikes in workload, irrespective of method used resulted in an increased risk of injury at higher ACWR ranges, and 3) higher relative chronic workloads for high-speed distance for slower players may offer a protective effect against injury, while higher absolute chronic workloads for high-speed distance may increase the likelihood of injury. These findings support earlier work, and suggest that practitioners should consider the running demands of each player on an individual basis.

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“The Use of Relative Speed Zones in Australian Football: Are We Really Measuring What We Think We Are?”

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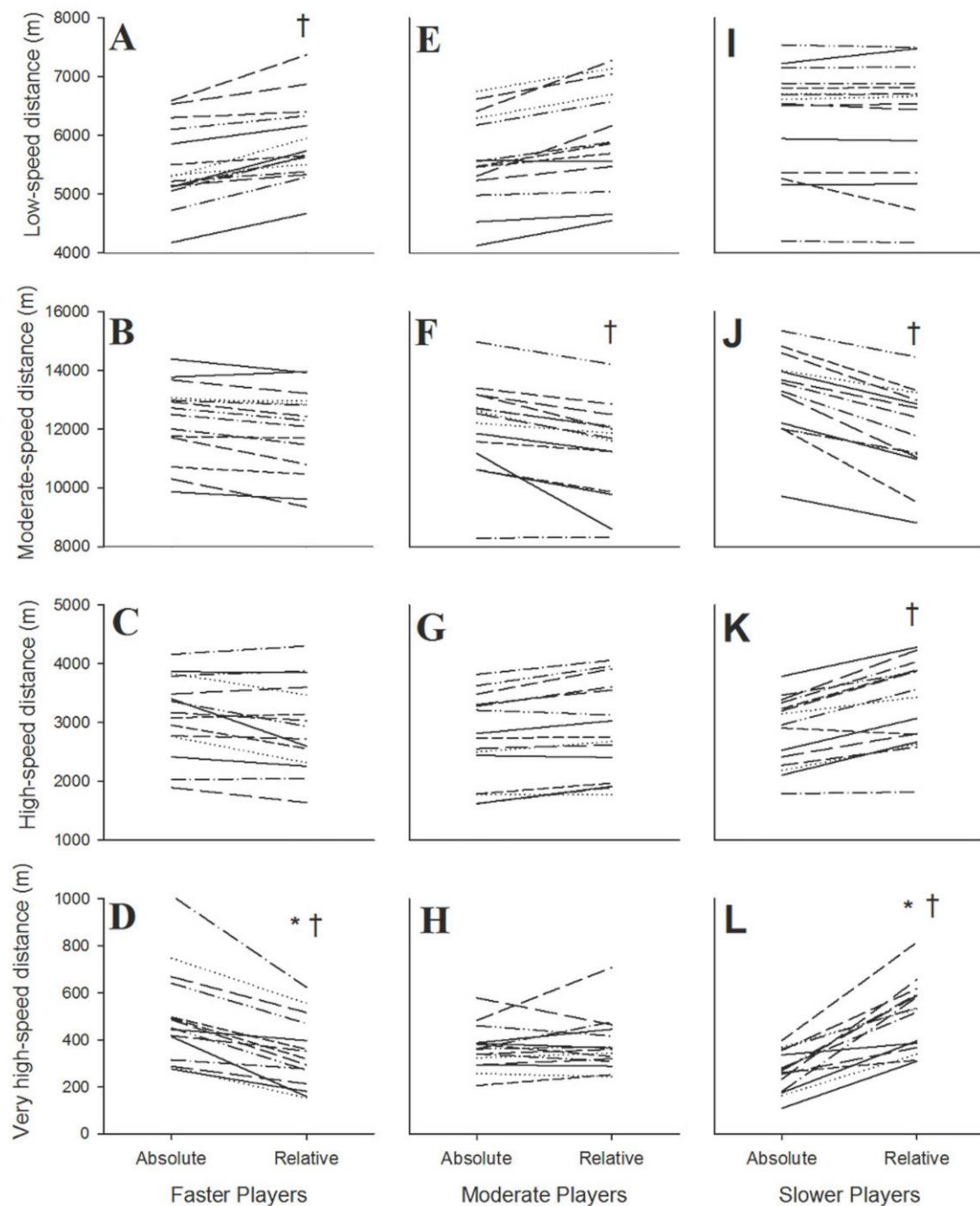


Figure 1. Absolute and relative average weekly workloads of faster (a, b, c, d) and slower (i, j, k, l) players across the duration of the pre- and in-season periods. * Denotes significant ($p < 0.05$) difference from absolute workload. † Denotes a practically meaningful (likelihood $\geq 75\%$) difference from absolute workload.

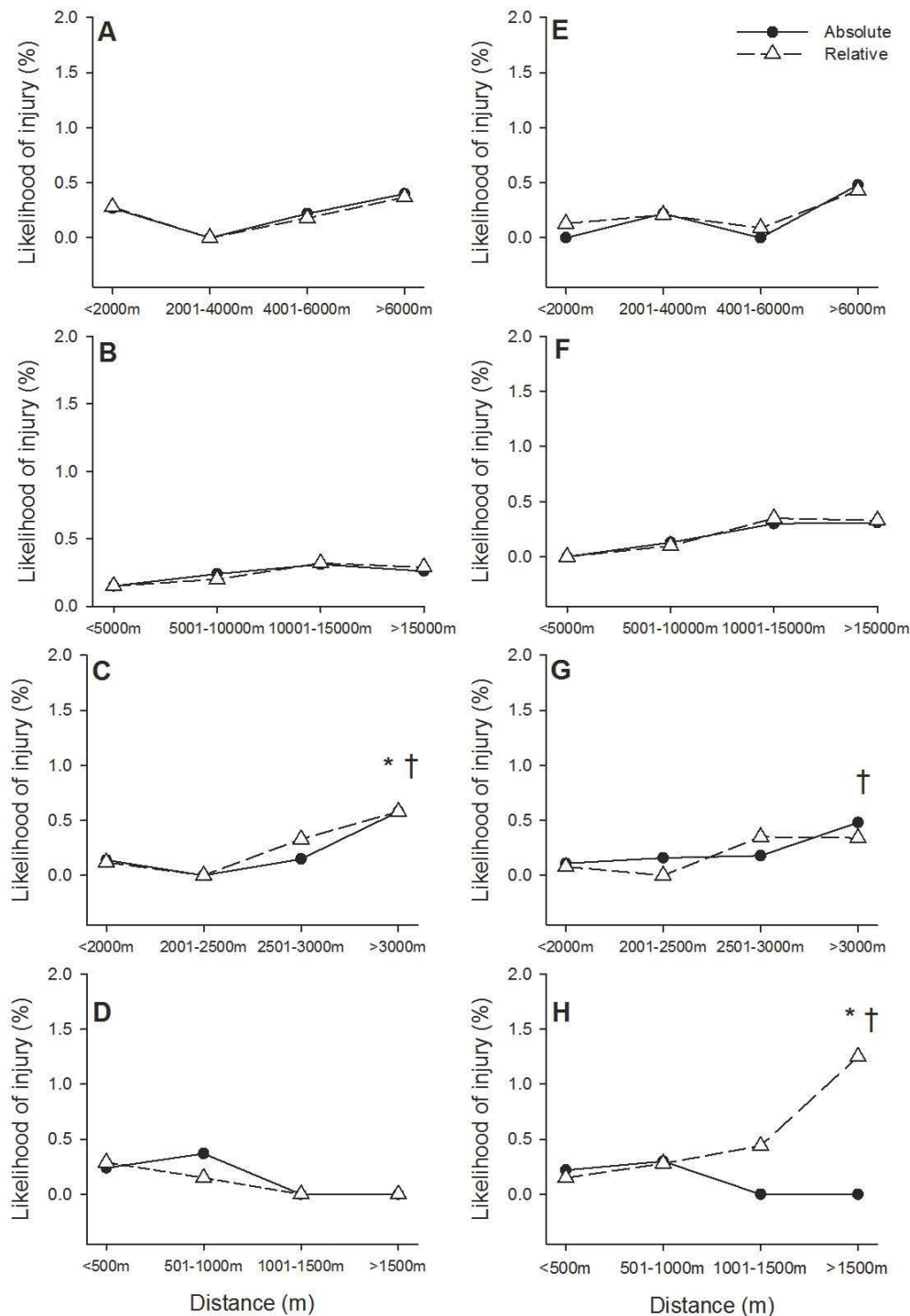


Figure 2. Likelihood of injury at differing acute workload ranges for faster (low-speed, A; moderate-speed, B; high-speed, C, very high-speed, D) and slower (low-speed, E; moderate-speed, F; high-speed, G, very high-speed, H) players. * Denotes a significant ($p < 0.05$) difference from the reference group. † Denotes a practically meaningful (likelihood $\geq 75\%$) difference from the reference group.

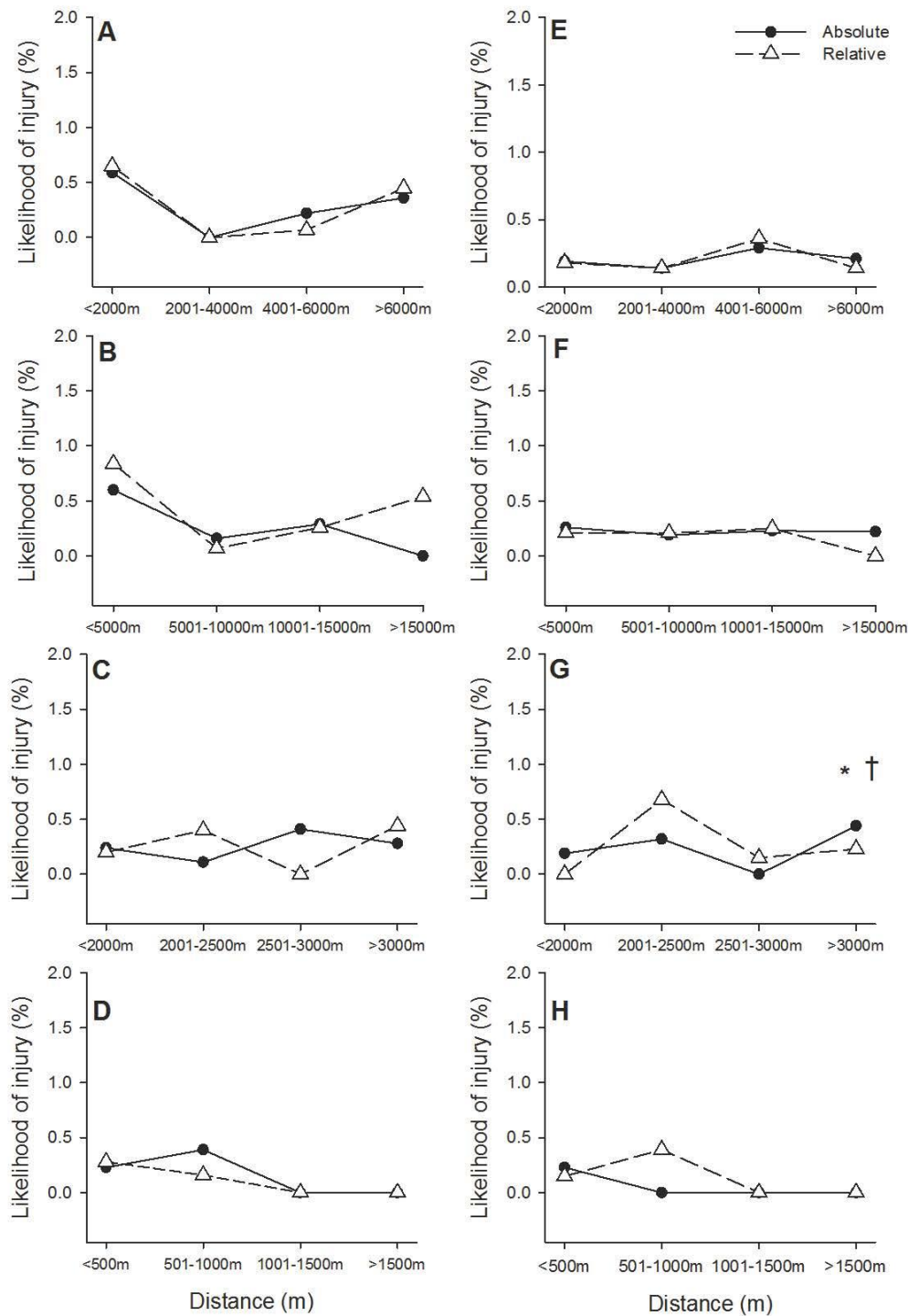


Figure 3. Likelihood of injury at differing chronic workload ranges for faster (low-speed, A; moderate-speed, B; high-speed, C, very high-speed, D) and slower (low-speed, E; moderate-speed, F; high-speed, G, very high-speed, H) players. * Denotes a significant ($p < 0.05$) difference from the reference group. † Denotes a practically meaningful (likelihood $\geq 75\%$) difference from the reference group.

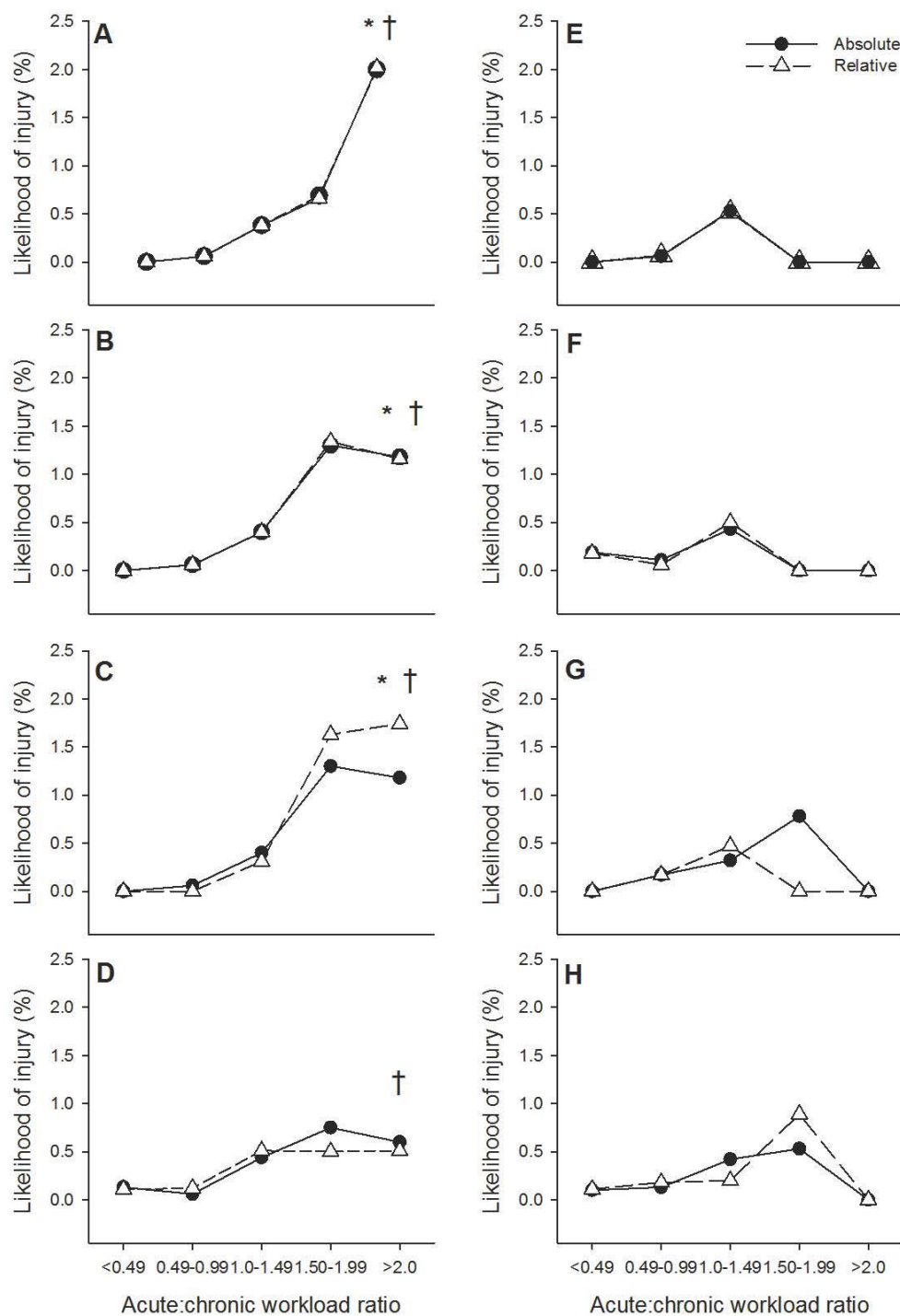


Figure 4. Likelihood of injury at differing acute:chronic workload ratio ranges for faster (low-speed, A; moderate-speed, B; high-speed, C, very high-speed, D) and slower (low-speed, E; moderate-speed, F; high-speed, G, very high-speed, H) players. * Denotes a significant ($p < 0.05$) difference from the reference group. † Denotes a practically meaningful (likelihood $\geq 75\%$) difference from the reference group.

Table 1. Weekly descriptive statistics for all participants’ external workload variables, both absolute and relative, over the duration of the study.

Variable	Absolute workload	Relative workload	P value	Effect size (90% CI)	Likelihood	%CV	SWC%	Prob. change%	Actual diff%
All Players									
LSD (m)	5766.6 ± 3209.3	6041.2 ± 3358.3	0.29	0.23 (-0.13–0.58)	55% Possibly	4.5	3.5	8.0	4.0
MSD (m)	12375.4 ± 6266.8	11611.8 ± 5842.5 *†	0.03	-0.45 (-0.80–0.11)	89% Likely	3.9	2.4	6.3	6.9
HSD (m)	2704.9 ± 1726.4	2929.3 ± 1889.0	0.21	0.27 (-0.08–0.62)	63% Possibly	11.3	5.7	17.0	11.8
VHSD (m)	371.1 ± 284.1	443.7 ± 436.3	0.16	0.30 (-0.05–0.65)	68% Possibly	40.1	8.4	48.5	35.6
Faster Players									
LSD (m)	5472.8 ± 681.7	5865.2 ± 679.2 †	0.13	0.56 (-0.04–1.17)	84% Likely	2.9	2.4	5.3	7.0
MSD (m)	12353.8 ± 1297.4	11992.9 ± 1423.6	0.47	-0.27 (-0.89–0.36)	57% Possibly	2.0	2.4	4.4	3.1
HSD (m)	3132.1 ± 673.6	2955.8 ± 757.2	0.51	-0.25 (-0.88–0.38)	55% Possibly	6.7	5.2	11.9	6.6
VHSD (m)	495.2 ± 201.8	342.0 ± 146.4 *†	0.02	-0.81 (-1.38–0.23)	96% Very Likely	16.6	8.6	25.2	38.1
Moderate Players									
LSD (m)	5458.4 ± 947.0	5826.4 ± 1031.9	0.32	0.37 (-0.25–0.99)	68% Possibly	3.0	3.8	6.8	6.5
MSD (m)	12103.6 ± 1546.6	11323.0 ± 1582.7 †	0.18	-0.49 (-1.10–0.12)	79% Likely	4.3	2.9	7.2	6.8
HSD (m)	2703.7 ± 749.6	2884.0 ± 803.1	0.53	0.23 (-0.39–0.86)	54% Possibly	4.3	6.1	10.4	6.6
VHSD (m)	362.8 ± 92.8	398.7 ± 136.9	0.41	0.31 (-0.32–0.94)	61% Possibly	15.9	5.9	21.8	7.5
Slower Players									
LSD (m)	5462.7 ± 1391.3	5425.7 ± 1501.7	0.94	-0.03 (-0.66–0.61)	40% Possibly	4.5	6.7	11.2	1.4
MSD (m)	12724.1 ± 2216.3	11464.6 ± 2199.7 †	0.13	-0.56 (-1.16–0.05)	84% Likely	3.5	4.5	8.0	10.8
HSD (m)	2772.8 ± 890.1	3457.8 ± 1105.4 †	0.07	0.66 (0.06–1.25)	90% Likely	8.8	7.7	16.5	21.7
VHSD (m)	267.5 ± 85.6	503.0 ± 146.9 *†	0.01	1.40 (0.95 to 1.85)	99% Almost Certain	24.8	6.9	31.7	61.3

All data are mean ± SD. Data were calculated for all players from every main, modified, or rehabilitation session completed across the pre- and in-season period. LSD = low-speed distance. MSD = moderate-speed distance. HSD = high-speed distance. VHSD = very high-speed distance. %CV: coefficient of variation percentage; SWC%: smallest worthwhile change (0.2 x between subject standard deviation). Prob. change%: minimum criterion change required to produce a probable significant change in performance. Actual diff%: the actual percentage difference in variables between workload conditions (i.e. absolute and relative).

* Denotes significantly different from absolute workload.

† Denotes practically meaningful difference from absolute workload.