

# Halftime Re-Warm Up Influences Second Half Soccer Performance: A Competitive Match Analysis

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Soccer | Recovery | Half-time | Re-warm up

## Headline

Activities performed during the halftime interval of a soccer match can positively influence performance in the early stages of the second half (1,4,6,7,8,16). Accordingly, Russell et al. (12) present a detailed strategy for optimizing halftime practices; including, a brief (3-4 min) period of re-warm up (RWU). However, Towlson et al. (13) found that there are limitations to the application of a RWU during competition.

**Aim.** While excellent justification exists for a halftime re-warm up, previous studies demonstrate a compromised ecological validity relative to competitive match conditions. As the nature of a competitive match may influence the effects of a RWU, this study examined the relationships between workload performed during soccer halftime and performance during the initial stages of the second half.

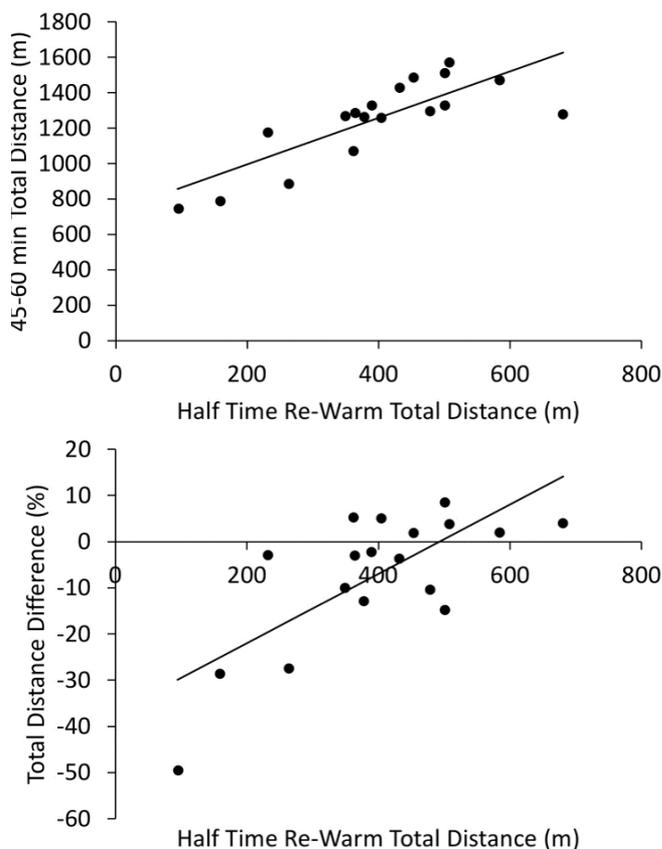
## Methods

**Athletes.** Players from an NCAA Division I collegiate soccer team ( $n=13$ ,  $167.9 \pm 1.1$  cm,  $63.6 \pm 1.2$  kg, mean  $\pm$  SEM), competing in eighteen regular season competitive matches were analyzed. Ethical approval was granted by the Virginia Tech Institutional Review Board and informed consent was obtained prior to data collection.

**Design.** This study is a retrospective, case study. It was conducted in the natural setting of competitive matches without intervention by the investigators. It aimed to compare metrics of workload during halftime RWU period to that of the first 15 minutes of the second half. To be included, players must have played at least 35 minutes of the first half, fully participated in all halftime activities, and played the entire first 15 minutes of the second half. Typically, 8-10 players per match fit these criteria, resulting in 154 player - matches.

As the data for this study were collected during competitive competitions, halftime activities varied between matches and were not controlled by the investigators. During halftime, players typically walked to the locker room, participated in team discussions and addressed various medical and equipment needs. Players also consumed fluids and carbohydrates ad libitum. Players then returned to the bench area where they engaged in RWU activities. In some cases, the RWU activities were structured and directed by management/support staff. In others, they were player-led and less structured. The RWU included various combinations of jogging, moderate paced sprints and change of direction movements as well as small-sided games. Due to factors such as the time spent in the locker room, weather conditions, and medical treatment, the RWU period varied in duration, volume and intensity of activity.

**Methodology.** To determine the volume and intensity of activity, players were fitted with a 15Hz GPS system (SPI HPU, GPSports, Canberra, Australia) and a heart rate (HR) monitor (T34, Polar, Bethpage, NY, USA). After each match, data were downloaded from the GPS units and sessions were "split" into 15-min match intervals as well as the half-time interval. Team AMS software (GPSPORTS) was used to determine the following nine variables: total distance (TotDist, m), speed exertion (SpE, au), sprints (Spr, occurrences where speed was maintained above 90% of maximal for  $\geq 1$  sec, n), body load (BL, au), high metabolic power distance (HMPDist, distance above 20 W·kg<sup>-1</sup>, m), high speed distance (HSDist, distance above 60% of maximal, m), low speed distance (LSDist, distance above 6km·hr<sup>-1</sup> and below 40% of maximal, m), heart



**Fig. 1.** Relationships between the TotDist during the halftime RWU and TotDist during the first 15 min of the second half (top) and the percent change in TotDist from the first to second half (bottom). Each data point represents the average of one match.

**Table 1. Comparisons of the halftime RWU values for match tertile.**

Variable	Tertile			Cohen's d		
	TL	TM	TU	TL v TM	TL v TU	Tm v Tu
TotDist (m)	242.11 ± 104.66	402.32 ± 33.70	540.93 ± 76.69	2.06	3.26	2.34
SpExert (au)	647.54 ± 243.28	1045.64 ± 36.31	1194.74 ± 133.14	2.29	2.79	1.53
Spr (n)	0.00 ± 0.00	0.11 ± 0.07	0.72 ± 0.40	2.27	2.58	2.15
BL (au)	1.73 ± 0.46	2.90 ± 0.39	4.95 ± 1.02	2.77	4.10	2.67
HMPDist (m)	7.35 ± 1.50	13.31 ± 2.82	30.02 ± 3.73	2.65	7.97	5.05
HSDist (m)	0.53 ± 0.34	3.13 ± 1.06	14.29 ± 8.24	3.30	2.36	1.90
LSDist (m)	52.86 ± 22.51	106.56 ± 17.16	150.81 ± 14.88	2.68	5.13	2.76
AvgHR (beats·min <sup>-1</sup> )	108.01 ± 6.22	123.01 ± 1.58	130.99 ± 3.71	3.30	4.49	2.80
HRExert (au)	22.14 ± 3.99	28.05 ± 0.69	35.28 ± 4.80	2.06	2.98	2.11

Effect Sizes: a small (r=0.1-0.3), b medium (r=0.3-0.5), c large (r>0.5). All others, trivial (r<0.1).

**Table 2. First-order correlation coefficients between variables determined during the halftime RWU period and the first 15 minutes of the second half (45-60 min interval).**

		45-60 min Interval								
		TotDist	SpE	Spr	BL	HMPDist	HSDist	LSDist	AvgHR	HRE
Halftime Re-Warm Up	TotDist	0.80c	0.71c	0.18a	0.76c	0.85c	0.52c	0.55c	-0.29a	0.65c
	SpE	0.73c	0.74c	0.42b	0.83c	0.79c	0.55c	0.21a	-0.22a	0.54c
	Spr	0.07	-0.30b	-0.30b	-0.07	-0.08	0.19a	-0.34b	0.15a	-0.14a
	BL	0.16a	0.04	-0.07	0.20a	0.18a	0.54c	0.06	0.28b	0.34b
	HMPDist	0.23b	-0.01	-0.14a	0.13a	0.20a	0.24a	0.00	0.14	0.38b
	HSDist	0.04	-0.22a	-0.38b	-0.11a	-0.12a	0.39b	-0.45b	0.31b	-0.09
	LSDist	0.66c	0.32b	0.17a	0.55c	0.65c	0.29a	0.69c	-0.37b	0.53c
	AvgHR	0.63c	0.82c	0.16a	0.63c	0.64c	0.36b	0.25a	-0.08	0.72c
	HRE	0.38b	0.27a	-0.11a	0.31b	0.35b	0.49b	-0.19a	0.28a	0.67c

Effect Sizes: a small (r=0.1-0.3), b medium (r=0.3-0.5), c large (r>0.5). All others, trivial (r<0.1).

**Table 3. First-order correlation coefficients between variables determined during the halftime RWU period and the difference between the initial 15 minutes of the first and second halves (45-60 min minus 0-15 min).**

		45-60 min Interval								
		TotDist	SpE	Spr	BL	HMPDist	HSDist	LSDist	AvgHR	HRE
Halftime Re-Warm Up	TotDist	0.73c	0.81c	0.43b	0.81c	0.80c	0.60c	0.55c	-0.11a	0.50c
	SpE	0.69c	0.63c	0.61c	0.73c	0.64c	0.41b	0.29a	-0.29a	0.36b
	Spr	-0.01	-0.18a	-0.31b	0.05	-0.16a	-0.12a	-0.25a	0.16a	0.08
	BL	0.12c	0.06	-0.07	0.14a	0.01	0.23a	-0.15a	0.21a	0.25a
	HMPDist	0.17c	0.18b	-0.01	0.16a	0.07	0.25a	-0.02	0.34b	0.28a
	HSDist	0.04	-0.10a	-0.36b	0.02	-0.13a	-0.10a	-0.24a	0.18a	0.06
	LSDist	0.45b	0.49b	0.29a	0.60c	0.48b	0.37b	0.42b	-0.15a	0.43b
	AvgHR	0.61c	0.83c	0.52c	0.59c	0.57c	0.49b	0.42b	0.02	0.29a
	HRE	0.50c	0.46a	0.13a	0.29a	0.25a	0.44b	0.18a	0.30b	0.46b

Effect Sizes: a small (r=0.1-0.3), b medium (r=0.3-0.5), c large (r>0.5). All others, trivial (r<0.1).

rate exertion (HE, au), and average HR (AvgHR, beats·min<sup>-1</sup>). SpE HRE, and BL scores were computed using proprietary algorithms. These variables were selected as they represent volume (TotDist, BL), intensity (HMPDist, HSDist, LSDist, AvgHR, Spr) and combinations of the two (SpE, HRE).

### Statistical Analysis

Mean values were compared using effects sizes (Cohen's d) and classified as trivial (<0.2), small (0.2-0.5), medium (0.5-0.8), large (0.8-1.3) and very large (>1.3). Pearson correlations were used to determine the strength and direction of the relationships between the halftime RWU and second half match performance. Effect sizes were classified using correlation coefficients as trivial (<0.1), small (0.1-0.3), moderate (0.3-0.5) and large (>0.5).

### Results

Per NCAA rules, halftime period is 15 min. The time spent in the RWU (active time) varied between matches with an av-

erage of 4.76 ± 0.26 min and a range of 2.2 to 5.5 min. The volume and intensity of the RWU varied considerably across matches. To examine this variability, match variables were divided into lower, middle and upper tertiles (TL, TM and TU, n=6). Table 1 shows mean values for the three tertiles. Very large effect sizes were found for all variables when comparing the tertiles with Tu > TM > TL. Figure 1 (top) shows the relationship between the TotDist covered during the RWU period and TotDist covered during the start of the second half (45-60 min). As physical demands vary between matches, the percent difference between first and second half, TotDist covered in the second half is expressed as a percentage of that covered during the first half (0-15 min) (Figure 1, bottom). As can be seen, there is a positive relationship between the halftime RWU and performance in the second half. The relationships between all variable of the halftime RWU and performances during the 45-60 min interval are shown in Table 2. There were large effect sizes for correlations between TotDist covered during halftime and each of the second half performance variables except Spr and AvgHR. Large effect sizes were also found between SpE and each of the 45-60 min performance

variables except Spr, LSDist and AvgHR. AvgHR was closely associated with second half TotDist, SpE, BL, HMPDist and HRE. Table 3 shows the relationships between the RWU and second half performance expressed as a percentage of first half. In general, the strength of the relationships in this analysis reflected those of Table 2. Second period performance between the TU and TL RWU matches are shown in Figure 2. In this figure, TU and TL matches were defined by TotDist (see Table 1). When more TotDist was covered during the RWU (TU), the change in performance from 0-15 min to 45-60 min was smaller compared to less TotDist covered (TL). In fact, much of the reduction in second half performance was eliminated by increased TotDist during the RWU. Similar findings were found when grouping matches based on RWU HMLDist and AvgHR.

**Discussion**

This study shows the workload performed during the halftime period (RWU) is positively associated with performance during the second half of competitive soccer matches. The results are consistent with previous controlled studies (1,4 6,7,8,16). More importantly, these findings add ecological validity to the concept that a halftime RWU positively influenced second half physical performance.

Edholm et al. (4) and Mohr et al. (5) found that a re-warm up consisting of 7 min of low to moderate activity that raised HR to  $\approx 70\%$  of maximal values was effective in improving second half performance. Others have shown that various types of RWU activities improve performance such as leg press (16), small-sided games (16), plyometrics (1), change of direction exercises (1,7) and whole-body vibration (7). Carling et al. (3) suggest that the number of high intensity efforts is an important marker of physical performance. In the present study, the halftime RWU metrics most closely associated with second half intensity markers were TotDist (volume), AvgHR (intensity) and SpE (combination of both). The AvgHR attained was approximately 60% of maximal and 72% of HR reserve. Further, the average duration of the RWU was less than 5 min. Thus, when taken as a whole, previous reports as well as the present data suggest that a RWU of 4-5 min consisting of a moderate volume of activity (400-400 m TotDist), interspersed with high intensity efforts (20-30 m) designed to raise

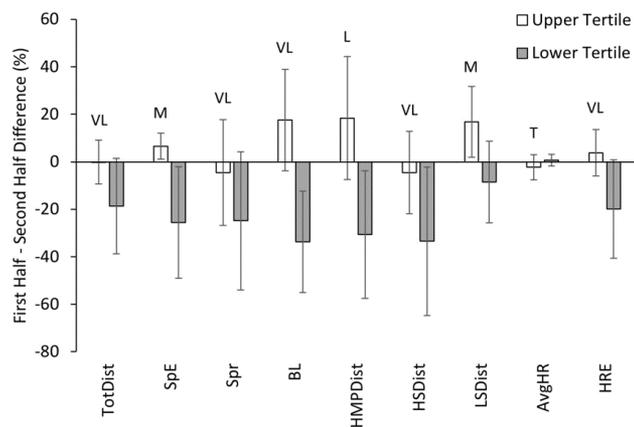
HR to 60-70% of maximal would be effective in facilitating second half performance. Much of the interest in the halftime RWU has focused on maintenance of muscle and body temperature during the mid-competition recovery period. An active RWU clearly reduces the halftime decline in temperature and improves subsequent performance (4,6,8). However, passive muscle heating did not improve second half soccer performance (6) whereas whole body warming did improve rugby performance (10,11). Thus, it is not clear if an active RWU affects performance via muscle thermoregulation or other factors. An inactive recovery during the halftime period, coupled with carbohydrate consumption could result in reduced blood glucose concentrations. Early studies (2,5) show that consuming carbohydrates prior to exercise often elevate blood glucose, followed by a large insulin response. As a result, glucose levels decline resulting in a rebound hypoglycemia. It is not clear if this happens during the halftime interval, particularly when combined with carbohydrate consumption. However, Wahren et al. (14) found that insulin levels rise quickly after exercise, reaching a peak within five minutes. Further, Russell et al. (9) found reductions in blood glucose following an inactive halftime, extending into the first 15 min of the second half. It is possible engaging in RWU during halftime may attenuate a possible rise in post-exercise blood insulin and limit reductions blood glucose that may otherwise be present at the start of the second half. At present, there is only circumstantial evidence to support this idea. More investigation of the interactions between exercise recovery, carbohydrate consumption and blood glucose and insulin is needed.

**Practical Applications**

- The results of this study are consistent with previous research concerning the value of a halftime RWU and support the contention that modest physical activity performed during the halftime interval can positively impact second half performance.
- It recommended that coaches consider utilizing a halftime RWU lasting 4-5 min, consisting of a moderate volume of activity, interspersed with high intensity efforts (sprints and changes in direction) designed to elevate HR to 60-70% of maximal.
- Such a RWU may attenuate reductions in muscle and body temperature as well as limit possible declines in blood glucose.

**Limitations**

- This study examined competitive, collegiate soccer matches. As it is a retrospective case study, the investigators did not intervene in the halftime RWU. Also, the study did not provide a control of comparison group. Thus, multiple factors may have impacted match performance independent of the RWU. For example, weather, strength of the opponent, playing style, and score-line varied between matches. Player health, training status, and recovery days were not controlled or monitored by the investigators.
- Player fitness, playing time and player participation may have contributed to the results. For example, fitter players could have performed more work during the RWU and in the second half. Also, less-fit players may have been excluded from all or part of a match which could have impacted average team performance for a given match.
- Match-to-match variations in halftime hydration and energy intake could have impacted the results. Further, player intake of other supplements, equipment adjustments and



**Fig. 2.** Differences in second half performance between TU and TL matches. Values are percent difference between the 0-15 min and 45-60 min interval and are expressed as mean  $\pm$  SD. Effects sizes between the upper and lower matches are identified (T=trivial, M=medium, L=large, VL=very large).

medical treatments during halftime were not controlled or monitored.

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