



PACK RUNNING AMONG FEMALE NCAA COLLEGIATE CROSS COUNTRY TEAMS

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Abstract:

The purpose of this study was to identify if there was a relationship between running with a teammate(s), often referred to as packing, during a cross-country race and lower aggregate team times of the top five scoring runners. This study examined packing strategies of Division 1 NCAA female cross-country runners. Packing was defined as any team member running within a second of a teammate at a given checkpoint during the race. All competitors across three women's races wore chip-timing bibs that recorded each competitor's time at checkpoints throughout the race. Only teams having five or more runners were included in the analysis. A "packing score %" was calculated for each team by dividing the number of times a runner was within a second of a teammate at a checkpoint in a given interval by the total number of packing opportunities within the interval (PS%). The total scoring team time was then calculated from the finishing time of each team's top five runners (Team Aggregate Time-TAT). The correlation coefficient between PS% and TAT was $r = -0.47$ ($p < 0.001$). While more research is needed to identify how and when packing should be optimally used, empirical findings indicate packing is beneficially associated with team running times.

Keywords: packing, distance running performance, coaching strategies, running strategies, group running, team performance

1. Introduction

Many long-distance running coaches encourage their athletes to utilize the strategy of racing and working together as a team, colloquially this strategy is termed "pack running", over running alone (Stevenson 2016) (Figure 1). The actual use and efficacy of

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pack running during team-based racing events, such as cross-country, is unknown but the study of human sociology, psychology, and physics, in addition to prevailing wisdom within the sport, suggest a benefit.

Throughout history, humans have worked in groups to economize labor, engage socially, and align social behaviors (Raafat et al. 2009). These phenomena support the idea that an individual's athletic performance may also be improved when participating as a member of a group but little empirical evidence exists to quantify if and how these group packing strategies affect individual and team running performance. Some research has examined the effects of social laboring, or social facilitation, defined as performance increases when in a group or team environment compared to performing alone. Hoigaard et al. (2013) showed increased performance in a 3-minute team time trial ($p < 0.05$) as a result of laboring alongside cycling teammates with whom they had participated in team cohesion activities. This result should beg the question as to whether there is a similar performance benefit among athletes in other sporting disciplines.

Another common explanation for the potential performance benefits associated with packing is the effect of drafting or running behind another runner to help negate the effects of wind or air resistance. A study done by Davies (1980) found that the energy costs related to overcoming air resistance on a still day was 7.8% for sprinting (10 m/s), 4% middle-distance (6 m/s), and 2% marathon (5 m/s) running. Another study done by Pugh (1971) found that at 4:30 min/mile pace, drafting behind another runner by one meter saves roughly 80% of the energy that would otherwise be spent fighting air resistance. Most recently, Zouhal et al (2015) found that drafting during a timed 3000-meter run had a significant positive effect on performance compared to not drafting (544.74 ± 18.72 vs. 553.59 ± 22.15 s, $p < 0.05$). In this study, runners also perceived drafted efforts as less strenuous as measured by the Borg Rating of Perceived Exertion scale (13.1 ± 1.3 vs. 16.1 ± 0.8 , $p < 0.05$) (Zouhal et al. 2015). However, this effect could not be explained in the study by physiological factors such as reduced energy expenditure or cardiorespiratory effort. This was evidenced by no statistically significant differences ($p > 0.05$) between drafting and non-drafting conditions, respectively, for heart rate (203 ± 14 vs. 198 ± 7 bpm), V_{O2} (68.6 ± 6.9 vs. 64.9 ± 8.3 mL*min⁻¹*kg⁻¹), ventilation (158.6 ± 21.4 vs. 139.9 ± 17.7 L/min), or respiratory exchange ratio (1.17 ± 0.15 vs. 1.07 ± 0.08) (Zouhal et al. 2015). Zouhal suggests that the ergogenic effect of drafting may be both physiological and psychological, and posits several possible explanations including the possibility that pacers may act as a "placebo" effect or as a distractor (2015). Other possible explanations suggested by Zouhal include physiological factors not considered in the study, namely improved biomechanics and aerodynamics. A similar study done by Corvalan-Grossling (1995) examined runners drafting in the "aerodynamic shadow" of a runner leading and found that drafting directly behind reduced both oxygen consumption (leading: 4.02 ± 0.18 vs. drafting: 3.81 ± 0.13 L/min, $p < 0.05$) and carbon dioxide production (leading: 3.74 ± 0.23 vs. drafting: 3.32 ± 0.13 L/min, $p < 0.05$) in the drafting runner. However, minute ventilation and heart rate were not significantly reduced by drafting. Similar results were found in a drafting position behind and to the inside of the leading runner.

To date, and the best of our knowledge, only two studies have examined the patterns of pack running and performance in elite runners at championship races and potential gender-based differences in packing strategies (Hanley 2015; Hanley 2016). Hanley (2016) found that marathon runners who packed with the same opponents throughout the race slowed the least in the second half of the race ($p < 0.001$, men: $ES \geq 1.19$; women: $ES \geq 1.06$) compared to runners who moved between packs or ran alone. It was also found that women slowed less ($p < 0.001$, $ES = 0.44$) and were more likely to run a negative split than men ($p < 0.001$) (Hanley 2016). However, the races that Hanley examined were individual events; research examining the potential benefits of packing with teammates has not yet been explored.

Therefore, the purpose of this study was to evaluate packing strategies among Division 1 NCAA female cross-country athletes to determine if there is a relationship between packing and team performance. It was hypothesized that there would be a statistically significant negative linear relationship between the packing score and the aggregate team time of the top five runners.



Figure 1: NCAA Female Cross Country runners pack running
(image courtesy of Southern Utah University Athletics)

2. Methods

2.1 Participants, Race, and Checkpoint Selection

Three women's 6K races were analyzed. The three races were 2016 NCAA Division 1 Regional races: Women's Midwest, Women's South, and Women's West as shown in Table 1. All competitors wore chip-timing bibs that allowed each competitor's time to be recorded at the finish line, along with multiple checkpoints along the way. Only teams having five or more members (a full scoring team) were considered in this study. All checkpoints provided by the timing data were used to calculate packing percentages with the exception of start and finish checkpoints. Finish checkpoint data was used to calculate individual and team times. Results were obtained from the website

<https://www.tfrrs.org/>. IRB approval was sought and granted: IRB Approval #14-102018h.

For this study and like the definition used by Hanley (2016), packing was defined as any team member running within a second of a teammate at a given race checkpoint. A “packing percentage score” was calculated for each team by dividing the total number of packing runners on a team across all checkpoints by the total number of packing opportunities (total number of times the team could have been packing). A high packing score indicates a team that packs more, and a lower packing score indicates a team that packs less. While only the top five (scoring) runners’ times were used to calculate a team’s aggregate time, each team’s packing score included all seven runners to account for the influence of packing of non-scoring runners on scoring runners.

Table 1: Profile of Races: Checkpoints and Participants

Race	Women’s South	Women’s Midwest	Women’s West	Women’s Total
Checkpoints Used	2176m 3000m 5000m	800m 1000m 1500m 2000m 2500m 3000m 3250m 3500m 4000m 4500m 5000m	1000m 3000m 4000m 5000m	
# of Full Teams	30	33	20	83
# of Runners from Full Teams	197	226	134	557

2.2 Statistical Analysis

For each running race, checkpoint data was used to determine how many runners were within one second of a teammate and a packing score was calculated for each team by dividing the number of packing runners across all checkpoints by the number of total packing opportunities. The total scoring team time was then calculated from the finishing time of each team’s top five runners (Team Aggregate Time-TAT). A linear regression analysis was then employed to determine the relationship between the TAT) and packing score % (PS%). Statistical analysis was conducted with GraphPad Software ($\alpha \leq 0.05$).

3. Results

The current investigation examined three regional NCAA Cross Country events which included 557 female runners representing 83 teams. Team aggregate times (TAT) and PS% scores were calculated for analysis. The Pearson correlation coefficient (PCC or r) between the TAT and PS% for the full race was $r=-0.47$ ($p<0.001$), considered as moderate

(Ratner, 2009). The PCCs between the TAT and respective 1st half and 2nd half PS% scores were $r=-0.47$ ($p<0.0001$) and $r=-0.33$ ($p=0.0026$).

Regression analyses were then used to predict TAT as a function of PS%: for the full race PS% score as well as the 1st half and 2nd half PS% scores (Table 2). The linear equations of best fit suggest for each interval of increase in the PS% score there is a decrease in TAT. Packing observation records are listed in Table 3.

Table 2: Regression of Packing Score % (X) and Team Aggregate Time (Y-minutes)

Observation	Linear Equation of Best Fit $y = b_0 + b_1 \cdot x_1$	SEE	PCC (r)	95% Confidence Interval b_1
Women- Full Race Packing Score	$Y = 113.5 - 0.125 \cdot X$	3.8	-0.47*	-0.177:-0.074
Women 1st ½ Packing Score	$Y = 113.8 - 0.095 \cdot X$	3.8	-0.47*	-0.135:-0.055
Women 2nd ½ Packing Score	$Y = 110.6 - 0.077 \cdot X$	4.1	-0.33*	-0.126:-0.027

* $p<0.001$: all b_0 and b_1 were significant $p<0.001$

Table 3: Observed Packing

Checkpoints Observed	Full Race	1st Half	2nd Half
Observed Packing	1262	995	267
Total Packing Possibilities	3611	2017	1594

4. Discussion

The purpose of this investigation was to quantify the relationship between percentage of team packing (or PS%) during selected collegiate cross country running races and TAT for the scoring runners. Based on the races that were evaluated, a moderate negative linear correlation was found between the PS% score and TAT. Likewise, regression analysis suggested that TAT could be accurately estimated based on the PS% score with a SEE=3.8. Both analyses suggest that pack running is associated with a lower team running times.

It was also of interest to determine the impact of pack running during the 1st and 2nd half with regards to TAT. To answer that question, we first generated a residuals plot based on the Women's Full Race linear equation reported in Table 2. Visual inspection of the residuals plot was inconclusive with regards to heteroscedasticity. We then revisited the PCC's between the 1st and 2nd half PS% scores and the TAT: $r=-0.47$ and $r=-0.33$ respectively. The 1st half PS% scores appear to have a greater degree of association to the TAT than the 2nd half PS% scores. Finally, a regression analysis of 1st and 2nd half PS% scores as related to TAT suggested that packing during the 1st half may have a marginal impact on the TAT (b_1 1st half=-0.095 b_1 2nd half=- 0.077), noting that the 95% confidence intervals for b_1 1st and 2nd half overlap (see Table 2). Based on the aforementioned analyses we were unable to statistically conclude if pack running during the 1st and 2nd half impacts TAT equivalently. However, there is a marginal suggestion that pack running during the 1st half of the race maybe more beneficial with regards to TAT, and hence warrants further investigation.

One possible explanation for these results is that teams overwhelmingly showed higher packing scores for checkpoints in the first half of the race compared to the second half (78 of 83 women's teams), indicating that most teams value or employ some type of packing strategy early in the race, regardless of their finish performance. Another explanation is that in the last half of the race, successful teams may have individuals who know when to break away from a pack in the interest of maximizing individual (and team) performance. In this scenario, a higher packing score for checkpoints later in the race may not correspond to higher team performance. Future research should consider analyzing and comparing other portions of the race such as comparing the first third of the race to the second third of the race.

Other literature substantiates the benefits of pack running and suggests drafting as the primary mechanism, however, evidence of physiological benefit is mixed. As such, the benefits of pack running may be due, at least in part, to psychological mechanisms. In a qualitative study, researchers interviewed Canadian university cross country coaches and found that all interviewed coaches indicated that teammates with established cohesive relationships worked together more efficiently and successfully during competitions (Cormier 2015). Another study exploring the nature of interpersonal influences between teammates describes the effects of social facilitation as inducing higher confidence perceptions, increased accountability and ease of self-regulation (i.e. a perception that it was easier to train or compete with a teammate) (Evans et al. 2013). Since it has been shown that individuals have a limited supply of energy to contribute toward acts of volition (Baumeister et al. 1998), it seems reasonable that a runner competing among teammates will expend less effort on managing pace or putting away failure-oriented thoughts and be able to maintain a more positive disposition (Baron et al. 2009), thereby conserving regulatory energy.

Results from the present study indicate that packing with teammates is associated with better collective team performances. These findings are supported by previous research; Hanley's work examining running packs in half-marathon and marathon competitions also found that pack-running was associated with improved performances (2015). He attributed much of the success of pack running to properly identifying competitors of similar ability with whom to run (Hanley 2015). These collective findings provide strong empirical evidence of the benefits of pack running and can be applied in team-based running events. It is unclear if professional runners, who compete primarily as individuals, might gain some benefit from competing in a team environment, similar to the way that NCAA cross country competitions are structured. The primary limitation of the present study is that it is strictly descriptive in nature and does not provide an explanation or mechanism for why packing is associated with improved performance. Another potential limitation includes how the races were aggregated and analyzed; while all races were the same length (6Km), each had different elevation profiles, weather, and checkpoint data. Increased homogeneity of these extraneous variables may lead to superior analysis. While more research is warranted to identify the mechanisms by which packing may improve performance and when packing should be used for optimal performance improvements, the insights from this study lay the groundwork for

identifying packing as a useful strategy in team-based cross country running. Future research should also examine the strategic differences between pack running with competitors versus teammates, pack size (i.e. n), as well as the role that weather conditions or course profile play in utilizing packing strategies. Results from this study may help coaches, athletes, and researchers better understand if packing strategies benefit team running performances and the extent to which packing should be encouraged and utilized.

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Conflict of Interest Statement

The authors declare no conflicts of interest.

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