Ten simple rules for better running.

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ABSTRACT

Running is a popular and in many respects intuitive sport. Nonetheless, an extensive body of research literature supports and examines the science of running performance. Here, we used meta-analyses and systematic reviews directly associated with running performance to qualitatively describe ten simple rules for better running. Better running is defined as increases in speed, endurance, or reduced likelihood of injury. The general hypothesis topologically examined was that there is sufficient aggregated evidence to leverage effort and interventions for increased performance in running. This hypothesis was supported with significant big-picture evidence for several pillars of better running including training, recovery, and phenomenological levers specific to this sport. These trends are simplified into ten simple rules for runners and researchers alike.

INTRODUCTION

Running is a sport typically described as relatively rapid terrestrial movement. Nonetheless, speed is not the key criterion for defining running in this increasingly diverse sport because performance can also include endurance and ultra-long distances. Gait is primarily used and is identified by relatively low foot-contact time with the ground and an aerial component to steps (Granatosky Michael et al. 2018; Rubenson et al. 2004). It is increasingly popular globally (Li 2016; USATF 2003). Running is also frequently conceptualized as a natural and intuitive sport (Absire 2010; Heinrich 2002; McDougall 2011). The science of running performance is extensive with peer-reviewed publications, dedicated sport science journals, and books examining all dimensions of competition, movement, kinematics, physiology, and injury to list a few (Magness 2014). Broadly speaking, performance in running is defined pluralistically and can include increases in speed, increases in endurance, or reductions in likelihood of injury. Here, we used meta-analyses and systematic reviews directly associated with these three specific measures of running performance to qualitatively describe ten simple rules for better running. The general hypothesis examined was that there is sufficient synthesis evidence to leverage effort and interventions for increased performance in running.

Rules are meant to be broken. However, rules can be a powerful heuristic and mechanism to explore human behavior (Chong et al. 2013; Rodner and Litz 2013; H. Zhou Z. and Qiao 2018). Well-designed rules connect with inputs and assess needs (Song and Kim 2012). Rules can also accommodate creativity and personal beliefs (Z.-J. Zhou et al. 2010). The ten simple rules commentary was developed in computational biology over 10 years ago to describe and synthesize salient principles or pillars associated with evidence and best practices for any number of endeavours (Bourne 2005). Statistical inference and building more informative causal models also paralleled this discourse with a deeper insight and focus on how to build more intuitive models using disparate forms of evidence (Cox 2006; Liero and Zwanzig 2012). Collectively, this thinking suggests that simple rules based on evidence can inform behavioural models for many human choice sets including how to train as a runner. Rules should simplify, models should be adaptive, and statistical models should describe key processes. Meta-analyses and systematics provide an instant big-picture snapshot of some of the volume of the scientific research on running by formally summarizing evidence from sets of primary research studies (Lortie C.J. et al. 2015). Consequently, we used the Web of Science to search for publications in peer-reviewed journals that included running,

performance, and meta-analysis or systematic review in the title to capture the contemporary evidence supporting an analysis of better running. A total of 272 publications were returned using these terms and after duplicates and exclusion criteria for relevancy (i.e. synthesized speed, endurance, or injury research), a total of 70 synthesis studies summarized the science of running and performance. Each synthesis was analyzed, and the data across these reviews were extremely heterogenic (G. Stewart 2010). Thus, the trends across all syntheses were simplified into ten simple rules for runners and researchers alike. The goal was not to vote-count evidence (H. R. Rothstein et al. 2013) but to provide a broad heuristic model that emphasizes fluency and adaptability for increased running performance.

TEN RUNNING RULES

(1) Use elevation and hypoxic training to increase endurance. Hypoxia or a shortage of oxygen typically associated with changes in elevation was reviewed in three meta-analyses all documenting net adaptation benefits in endurance for runners (Bonetti and Hopkins 2009; Hamlin, Lizamore, and Hopkins 2018; Lancaster and Smart 2012). Training recommendations supported by 70 primary research studies across these reviews included live-high, train-low; high elevations at 2500m; and live at these elevations for at least 2 weeks or at least intermittently for 4 weeks to increase endurance. The general rule that was consistent across these syntheses is that relatively high elevation provides net adaptation benefits to running at lower elevations.

(2) Use cooling to increase endurance. Thermal stress impairs exercise performance including capacity, endurance, and speed (Marino 2004). Two meta-analyses documented returns in primary research studies testing performance differences with cooling and running (Ruddock et al. 2017; Tyler, Sunderland, and Cheung 2015). A total of 42 experiments were compiled, and both precooling and percooling improved endurance in self-paced trials particularly for prolonged exercise. Sprinting was not improved, and cold application directly to skin but not muscles was the most effective intervention.

(3) Resistance train to improve endurance. Resistance training for runners typically refers to weights or sled pulls to increase strength. Resistance training in this context was extensively reviewed with evidence for improvements in economy (Balsalobre-Fernández, Santos-Concejero, and Grivas 2016), speed (Blagrove, Howatson, and Hayes 2018; Yamamoto et al. 2008), and endurance (Alcaraz-Ibañez and Rodríguez-Pérez 2018; J. Wilson et al. 2011) collectively describing 1165 primary studies. In all syntheses, the optimal frequency of resistance was no more than twice per week. Moderate to heavy loads were recommended, but every synthesis also cautioned against high frequency of this intervention for runners.

(4) Do plyometrics for speed. Plyometric exercises for runners primarily use jump training (Rimmer and Sleivert 2000). Jump training was mentioned in many syntheses but explicitly summarized in a single meta-analysis that compiled 56 primary research plyometric studies for running (Sáez de Villarreal, Requena, and Cronin 2012). For elite runners, the consensus across all primary studies was that 10 weeks of at least 15 sessions per week at 80 high-intensity jumps (with no weight) consistently increased sprint speeds.

(5) Skip stretching if injury free. In many respects, stretching is the most controversial intervention for runners with conflicting evidence on benefits even for reduced likelihood of injury (Pope et al. 2000; Shrier 1999). A recent systematic review described evidence from 23 primary studies and concluded that stretching does improve performance in running as estimated by force, speed, or economy (Shrier 2004). A caveat to these conclusions is that this set of primary studies focussed on runners without injuries and not on muscle stiffness, recovery, or other indirect measures of potential predictors of performance.

(6) Train hard for endurance, train fast for speed. As described above in rule 3, endurance outcomes can most likely be enhanced by resistance training at modestly low frequencies but at high loads (J. Wilson et al. 2011). Two synthesis studies examined no resistance, high intensity sprint training as a mechanism to increase speed for very short duration running events (Taylor et al. 2015). These meta-analyses summarized evidence from a total of 45 controlled trials for sprint training and concluded that short sprints of either 20m (or 10 seconds) with a work-to-rest ratio of 1 to 0.25 (or 90 second recovery) for at least two weeks significantly increased running speed for most sprint distances.

(7) Recovery is critical. Recovery is discussed in many synthesis studies of running and performance; however, at the level of meta-analyses and systematics, only two reviews directly examined recovery via cold water interventions or icing as a passive means to facilitate performance for runners (Bleakley, Costello, and Glasgow 2012; Higgins, Greene, and Baker 2017). From the 58 research trials compiled,

cooling positively improved recovery through analgesic effects such as muscle soreness. Active versus passive recovery (Losnegard et al. 2015) has not been summarized using formal synthesis tools for runners. This gap presents a novel opportunity to explore recovery benefits on running performance. Evidence from the cooling and recovery research on 1271 runners tested to date strongly suggests recovery can be enhanced in this sport and is a critical overlooked performance dimension.

(8) Manage your relatively longer training distances. Ultra-runners sustain the most injuries of all categories of runners in a synthesis of 86 independent surveys (Kluitenberg et al. 2015). In two other syntheses of 45 studies, populations of long distance runners also experienced increasing likelihoods of injury with increased training distances (Lopes et al. 2012; Gent et al. 2007). The performance outcomes were thus typically net negative with distance and reported as lost time training. Distance runners, do not become your own worst enemy.

(9) Taper. Tapering is a reduction in training prior to a competitive event in most sports including running, and it is a commonly accepted intervention assumed to increase many measures of performance (Houmard et al. 1994). A contemporary meta-analysis of 182 studies concluded that a two-week taper of reduced training volumes from 41-60 percent increased performance (estimated as percent change in the many different measures examined in primary studies) (Bosquet et al. 2007). The pattern of taper, i.e. linear, exponential, fast or slow, was not testable because independent studies varied in their reporting of the interventions examined.

(10) Cultivate a goal-centric mental state. A single systematic review examined the psychology of ultra-runners compiling evidence for 51 studies and over 4500 athletes (Roebuck et al. 2018). This phenomenological approach to running performance compellingly identified mental state as a primary pillar of running performance – at least for endurance. The mental traits of *goal-driven* and *explore limits* were identified as critical factors for motivation and performance in this community of runners.

IMPLICATIONS

Collectively, the evidence used to propose these rules supports the hypothesis that substantive and sufficient research has been published examining running and performance. Meta-analyses and systematic reviews are commonly considered the gold standard of evidence syntheses because they describe many primary studies and seek to move knowledge beyond context specificity (C. J. Lortie 2014; G. B. Stewart and Schmid 2015). Here, the simplification to rules and a model for better running thus very parsimoniously restricted inference to these higher-level publications to ensure that broad trends were distilled for runners and those interested in examining the science of running. Running can be improved. Performance should be informed by evidence-based decisioning. Practitioners can engage with this scientific literature because the consensus across all synthesis studies here for running is that the net outcome of interventions summarized is a meaningful biological difference. An experimental mindset to running is a best practice. Next steps should include compiling individual, longitudinal training datasets for runners and personalizing the evidence for models of running using these rules for the specific goal at hand. Exploration of active recovery for runners in addition to recovery cooling is a research gap in the synthesis of primary research literature. Run like you know something – and we do.

ACKNOWLEDGMENTS

This synthesis was supported by Jaybird.

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