A SYSTEMATIC REVIEW: LONG RANGE CORRELATIONS IN RUNNING GAIT

Taylor J Wilson[1] & Aaron D. Likens[1]
[1]Department of Biomechanics, University of Nebraska at Omaha, Omaha, NE USA
Email: twilson50@unomaha.edu

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INTRODUCTION

Much research has been dedicated to measuring the health benefits of running, but only a few studies have examined how running patterns change over time. Long range correlations (LRCs) characterize the degree to which movements are correlated from one moment to the next. LRCs are found in many human activities, including walking and running. Assessing LRCs is important because the presence of LRCs has been associated with health, while the absence of LRCs has been noted as a marker of disease [2]. Hence, more research is needed to understand the meaning of LRCs in running gait.

A systematic review (SR) was completed to look at the effects of running gait on LRCs and the implications this could have on human health, performance, and rehabilitation. The aims of this review were to: identify the typical LRC patterns in human running gait, the effect that running/walking has on LRCs, the effect of injury/disease on running gait, and the effect that surface has on the LRCs of running gait.

METHODS

PRISMA guidelines were followed for this SR. PubMed, IEEExplore, Scopus and Web of Science were used until November 2020 using the SR tool Rayyan Qatar Computing Research Institute.

Inclusion criteria were: Experimental studies involving human subjects, running, and measurements of LRCs. Exclusion criteria were: Non-experimental studies, non-humans, walking only, non-running, non-LRC analysis, and non-experiments. Two independent raters (TW,AL) screened articles for inclusion. Raters settled disagreements through discussion.

RESULTS AND DISCUSSION

200 studies fell within our criteria. After review and deliberation between TW and AL, 20 articles were included in our SR. Our review revealed that, in general, gait characteristics of running seem indicative of LRCs and are similar to those found in walking gait. LRCs are apparent in both treadmill (TR) and overground running (OR). Results comparing OR and TR, however, are mixed, with some papers showing TR produces greater LRC [5], while others show the opposite trend [3].

Surprisingly, we did not find any studies comparing LRC as a function of health; however, two articles directly measured the effect of injury on the LRCs in running gait. One of those articles found only small differences in LRCs between injured and non-injured runners [6], compared to a significant difference in LRCs between the two groups, with a higher LRC in the non-injured runners [7]. Interestingly, the fatigue state of the runner may determine the magnitude of LRCs: One article showed a U-shaped trend in LRCs with highest levels of LRCs at the beginning and end of a run [8]. Other articles showed a linear decrease in LRCs with fatigue [1]. Running speed may produce a similar U-shaped LRC trend in running gait [5], but this effect was not consistent in this review [6].

CONCLUSIONS

We conducted this review to uncover the typical LRCs of running gait in several contexts. With mixed results, our review suggests that, like walking, running gait exhibits patterns of LRCs that seem to vary according to where running takes place and the state of the runner. If, as our review implies, fatigue produces measurable changes in LRCs, then tracking LRCs in a workout program could enhance injury prevention and speed up recovery. For instance, decreases in an athlete's LRC during training could be used to trigger suggestions for more rest and, ultimately, prevent injury. Our results also suggest new training possibilities that could enhance adaptability of the system. Training outside the preferred speed may increase LRCs, which could, in turn, improve recovery times and prevent injury. Furthermore, measuring LRCs of locomotion is highly recommended due to its good reliability [4], and non-invasive nature compared to other methods of recording fatigue, like taking lactate levels and measuring intramuscular EMG signals during a run.

More research is needed to determine how LRCs depend on running surface. This could have implications in sports performance and rehabilitation settings. By determining the surface that produces the highest LRCs, this will benefit coaches/physical therapists so that they can prescribe appropriate surfaces for their athletes/patients to improve healthier functioning. Lastly, our review suggests a strong need for further research into the timing of gait when running, due to mixed results concerning running surface, no research related to disease and running, and the relatively low number of papers that have investigated LRCs in this context.

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