Digital versus physical environmental scans to assess runnability in Metro Vancouver

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ABSTRACT

Running has a variety of benefits for mental and physical health. Despite the capacity of running to improve general wellbeing, little is known about environmental features related to running, what we call runnability. Freely available satellite imagery and street-level data provided by Google Earth potentially enables researchers to conduct environmental scans remotely, a time-saving and cost-effective alternative to physical scans. This study seeks to determine if digital scans are adequate for identifying environmental features associated with runnability. Strava, an increasingly popular fitness social media app, identified areas of high and low running volume in Metro Vancouver. A checklist of environmental features conducive to running was drawn from a literature review and previous survey results. The checklist then assessed selected high and low volume run areas digitally using Google Street View and Google Earth imagery. A team of two researchers also measured the same environments in person to determine the accuracy and comprehensiveness of the digital scans. In general, the physical scans captured more features and greater detail than the digital scans, and certain areas exhibited greater digital and temporal accuracy than others. Findings begin to explore the utility of digital environmental scans for runnability. As the scope of remote imagery coverage extends, digital scans will likely improve relative to physical audits.

1. Introduction

The built environment has a significant effect on physical activity (Badland et al., 2010; Ewing et al., 2014). Further, the surrounding environment impacts runner experience differently than walkers and cyclists (Shashank et al., 2022). However, environmental factors that impact running are under-researched (Pontin, 2021). Better insights into runner preferences and barriers to participation would help urban planners promote running. As illnesses linked to sedentarism increase in Canada, planning for active communities is critical (Dai et al., 2021). Running is an affordable and effective way to lower health risks linked to physical inactivity (Hitchings & Latham, 2017). Additionally, running has been found to improve psychological wellbeing (DeJong et al., 2021; Inoue et al., 2013; Kalak et al., 2012). Given the benefits of running, greater attention should be placed on structuring environments for runner experience.

Unprecedented volumes of highly granular data generated from location-based apps enable researchers to draw conclusions that were previously impossible. Strava is an increasingly popular social media application where users upload physical activities to track progress and connect with friends. In 2014, the crowdsourced fitness app Strava released Strava Metro, a commercial platform that provides aggregated and anonymized user information (Lee & Sener, 2021). Potential for Strava data to promote physical activity is immense, and insights have already been used to improve urban infrastructure for cyclists (Sun, 2017). Other studies have used

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Google Street View (GSV) to better understand the environments that contribute to physical activity through digital environmental scans (Bethlehem et al., 2014; Charreire et al., 2014; Griew et al., 2013). GSV is a web mapping service that provides detailed images of streets across the globe, with varying degrees of coverage, and enables researchers to assess the built environment remotely. Digital scans are potentially a great alternative to physical (in-person) environmental scans which typically incur significant financial costs and time demands (Ben-Joseph et al., 2013; Clarke et al., 2010; Odgers et al., 2012).

Though studies have found digital scans are adequately reliable compared to physical scans (Ben-Joseph et al., 2013; Clarke et al., 2010; Edwards et al., 2013; Taylor et al., 2011), sole reliance on GSV runs the risk of not detecting certain variables of interest. These studies concluded that digital audits can replace physical audits, though none to date have determined the efficacy of evaluating built environment features specific to running. Research on features that constitute conducive running environments, referred to as runnability, would be greatly improved by the incorporation of GSV imagery with Strava data. To our knowledge, there is only one published study which employs Strava data with GSV data to assess the influence of the built environment on running (Jiang et al., 2022). However, the conclusions were based solely on automated digital scans and variables were primarily selected from walkability studies. Before further adoption can occur, the accuracy and reliability of digital scans for measuring runnability of the built environment requires validation.

This study therefore extends the discussion over the reliability and validity of digital versus physical methods for assessing the built environment. We aim to evaluate the runnability of Metro Vancouver areas as a case study to compare these two methodologies. Study objectives are twofold, seeking to:

1. Identify environmental features that constitute a conducive running environment through a literature review.
2. Determine if digital scans are adequate for identifying environmental features associated with runnability in urban and suburban settings.

2. Methods & Data

2.1 Data

Three sources of data were used in this study. First, data of runs in Metro Vancouver during 2019, purchased from Strava, identified areas where the highest and lowest run volumes occurred. The Strava data are made of small segments that represent a network of routes taken by Strava users. Each unique segment is separated by its intersection with another segment and contains aggregated runner volumes for the entire year. The other two sources of data were gathered from GSV and physical scans of the selected Strava segments.

2.2 Methods

Physical and digital environmental scans were conducted for 20 locations in Metro Vancouver. Around 2/3 of the locations experienced high run volumes among Strava users, and the remaining areas recorded lower running volumes for 2019. Selected locations spanned Metro Vancouver, including a mixture of Strava segments in urban and suburban communities. An auditing tool was constructed to assess natural and built environmental features linked to runner preferences (*Table* 1). The tool is based on previous surveys of various runner populations and a literature review of runner studies. Inclusion parameters were strict, thus excluding studies that analysed runner preferences in conjunction with cycling or walking.

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Each category of the audit tool was weighted based on the number of studies finding a correlation with running. Within each category, several items were measured based on three categories (low, medium, high) or binarily (absent, present) (Wu et al., 2014). A higher score indicated a more conducive running environment, while a lower score reflected a greater number of features that hinder running. The measures were based on researcher perception rather than entirely quantitative measurements. A perception-based measure looks at how a space is felt and experienced by someone passing through. Though bias exists from person to person, comparisons can be drawn across environments to understand the geographic variation of runnability in Metro Vancouver.

Table 1: Audit tool based on preferred environmental characteristics among runners

Category	Item	Measure	Weight	Source
Natural Environment				
	Vegetation	0, 0.5, 1 (low, med, high)	2	(Jiang et al., 2022; Schuurman et al., 2021)
	Blue space	0, 0.5, 1 (low, med, high)	3	(Huang, 2022; Jiang et al., 2022; Schuurman et al., 2021; Yang et al., 2022)
	Green space	0, 0.5, 1 (low, med, high)	3	(Bodin & Hartig, 2003; Deelen et al., 2019; Edensor et al., 2018; Ettema, 2016; Harte & Eifert, 1995; Huang, 2022; Jiang et al., 2022; Schuurman et al., 2021; Yang et al., 2022)
Running Surface				
	Wide path	0, 0.5, 1 (low, med, high)	2	(Jiang et al., 2022; Schuurman et al., 2021)
	Well-maintained surface	0, 0.5, 1 (low, med, high)	2	(Ettema, 2016; RRCA 2021; Schuurman et al., 2021)
Traffic Hinderance				
	Distance from major road	0, 0.5, 1 (low, med, high)	2	(Deelen et al., 2019; Ettema, 2016)
	Pedestrian paths	0,1 (absent, present)	2	(RRCA 2021; Schuurman et al., 2021)
	Continuity (fewer path disruptions)	0, 0.5, 1 (low, med, high)	3	(Edensor et al., 2018; Harte & Eifert, 1995; Schuurman et al., 2021)
Infrastructure				
	Public toilets	0,1 (absent, present)	2	(RRCA 2021; Schuurman et al., 2021)
	Public water fountains	0,1 (absent, present)	2	(RRCA 2021; Schuurman et al., 2021)

A team of two auditors conducted digital scans of each of the locations using GSV imagery. Google Earth satellite imagery was used to complete audits in areas where GSV was unavailable. The degree of a feature's presence was recorded systematically by each researcher as they carefully navigated the GSV segment. Half of the scans were first completed digitally, and the other half were first conducted physically to account for any bias between the two approaches. The same two auditors visited the selected sites in person. The team catalogued features they observed based on the same auditing tool used before. For both scan types, rating criteria was clarified between auditors before scanning began, and scores were discussed after scanning was completed. Finally, the scores from the digital and physical scans were compared to assess the amount of difference in recorded values. The time taken to complete the physical and digital audits was observed for each location and compared to measure efficiency between the two data collection methods.

Figure 1: Images of the four sites assessed digitally and physically through environmental scans. Location 1 is the Vancouver Seawall in Olympic Village. Location 2 is an alley behind the intersection of Kaslo Street and 1st Avenue. Location 3 is a portion of the Lynn Valley Link in North Vancouver. Location 4 is a portion of the Spirit Trail in the City of North Vancouver.

3. Results

Similar to previous studies, the physical scans for runnability captured greater detail than digital scans and uncovered features overlooked by GSV imagery (Ben-Joseph et al., 2013; Charreire et al., 2014). Therefore, the scores resulting from digital and physical scans varied

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more in some locations than others (*Table 2*). Additionally, scores varied between researchers which highlights the different way places are perceived. An intraclass correlation coefficient (ICC) using a two-way mixed model was used to determine the level of agreement between digital and physical scans (Badland et al., 2010; Gullón et al., 2015). We found high overall agreement between digital and physical scans of the preliminary locations (ICC=0.946, *p*=0.028); however, the sample size was incredible small at preliminary stages which may not produce a reliable estimate. Upon further data collection, ICC will be used to measure the final reliability outcome.

Table 2: Scores from runnability audits for physical and digital environmental scans.

	Auditor 1		Auditor 2	
	Digital	Physical	Digital	Physical
Location 1	15	14	15	14
Location 2	2.5	5.5	4.5	3.5
Location 3	15	10	12.5	11
Location 4	14	17	15	19

Since GSV coverage varies depending on the accessibility of a location, areas where satellite imagery was used to replace GSV showed less feature accuracy but higher temporal accuracy (i.e., more recent image capture). Additionally, GSV coverage varies temporally which resulted in street-view imagery from over a decade ago being used for some locations (e.g., the Seawall near Olympic Village). Overall, the amount of time saved using digital scans was significant. Physical scans took 1.8 to 4.1 times longer to conduct than digital scans and incurred notable time and travel costs.

4. Discussion & Conclusion

In this study, the validity of using digital environmental scans in lieu of physical environmental scans using GSV was tested through the assessment of environments for runnability. This study highlighted differences in results based on physical or digital scan approaches. While in-person scans are preferred as they capture greater detail, digital cans appear to be a sufficient cost-effective alternative. This study also highlights the capacity of GSV data to better understand conducive running environments by developing an assessment tool specific to runner-identified preferences. Environmental scan studies are limited by their conceptualization of complex environmental phenomena. Methodological differences in the measurement and collection of built environment data related to physical activity severely limit cross-study comparability (Villanueva et al., 2013).

The auditing tool we developed is limited by the runner preferences identified. There are different preferences among runners depending on experience level, age, and gender (Deelen et al., 2019; Ettema, 2016; Harden et al., 2022). The runnability of an environment is subjective, however our metric includes the most widely reported features preferred by various categories of runners. Preliminary findings from this study will inform further analysis of the built environment for running to improve active community planning. Rapid advances in technology may eventually result in improved digital data that would facilitate digital scans while minimizing data loss. A future paper will expand the audit tool components and extend previous digital scan frameworks to runnability.

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References

Badland, H. M., Opit, S., Witten, K., Kearns, R. A., & Mavoa, S. (2010). Can Virtual Streetscape Audits Reliably Replace Physical Streetscape Audits? *Journal of Urban Health*, *87*(6), 1007–1016. https://doi.org/10.1007/s11524-010-9505-x

Ben-Joseph, E., Lee, J. S., Cromley, E. K., Laden, F., & Troped, P. J. (2013). Virtual and actual: Relative accuracy of on-site and web-based instruments in auditing the environment for physical activity. *Health & Place*, *19*, 138–150. https://doi.org/10.1016/j.healthplace.2012.11.001

Bethlehem, J. R., Mackenbach, J. D., Ben-Rebah, M., Compernolle, S., Glonti, K., Bárdos, H., Rutter, H. R., Charreire, H., Oppert, J.-M., Brug, J., & Lakerveld, J. (2014). The SPOTLIGHT virtual audit tool: A valid and reliable tool to assess obesogenic characteristics of the built environment. *International Journal of Health Geographics*, *13*(1), 52. https://doi.org/10.1186/1476-072X-13-52

Bodin, M., & Hartig, T. (2003). Does the outdoor environment matter for psychological restoration gained through running? *Psychology of Sport and Exercise*, *4*(2), 141–153. https://doi.org/10.1016/S1469-0292(01)00038-3

Brownson, R. C., Hoehner, C. M., Day, K., Forsyth, A., & Sallis, J. F. (2009). Measuring the Built Environment for Physical Activity. *American Journal of Preventive Medicine*, *36*(4), S99-S123.e12. https://doi.org/10.1016/j.amepre.2009.01.005

Charreire, H., Mackenbach, J. D., Ouasti, M., Lakerveld, J., Compernolle, S., Ben-Rebah, M., McKee, M., Brug, J., Rutter, H., & Oppert, J.-M. (2014). Using remote sensing to define environmental characteristics related to physical activity and dietary behaviours: A systematic review (the SPOTLIGHT project). *Health & Place*, *25*, 1–9. https://doi.org/10.1016/j.healthplace.2013.09.017

Clarke, P., Ailshire, J., Melendez, R., Bader, M., & Morenoff, J. (2010). Using Google Earth to conduct a neighborhood audit: Reliability of a virtual audit instrument. *Health & Place*, *16*(6), 1224–1229. https://doi.org/10.1016/j.healthplace.2010.08.007

Dai, H., Tang, B., Younis, A., Kong, J. D., Zhong, W., & Bragazzi, N. L. (2021). Regional and socioeconomic disparities in cardiovascular disease in Canada during 2005–2016: Evidence from repeated nationwide cross-sectional surveys. *BMJ Global Health*, *6*(11), e006809. https://doi.org/10.1136/bmjgh-2021-006809

Deelen, I., Janssen, M., Vos, S., Kamphuis, C. B. M., & Ettema, D. (2019). Attractive running environments for all? A cross-sectional study on physical environmental characteristics and runners' motives and attitudes, in relation to the experience of the running environment. *BMC Public Health*, *19*(1), 366. https://doi.org/10.1186/s12889-019-6676-6

DeJong, A. F., Fish, P. N., & Hertel, J. (2021). Running behaviors, motivations, and injury risk during the COVID-19 pandemic: A survey of 1147 runners. *PLOS ONE*, *16*(2), e0246300. https://doi.org/10.1371/journal.pone.0246300

Edensor, T., Kärrholm, M., & Wirdelöv, J. (2018). Rhythmanalysing the urban runner: Pildammsparken, Malmö. *Applied Mobilities*, *3*(2), 97–114. https://doi.org/10.1080/23800127.2017.1347361

Edwards, N., Hooper, P., Trapp, G. S. A., Bull, F., Boruff, B., & Giles-Corti, B. (2013). Development of a Public Open Space Desktop Auditing Tool (POSDAT): A remote sensing approach. *Applied Geography*, *38*, 22–30. https://doi.org/10.1016/j.apgeog.2012.11.010

Ettema, D. (2016). Runnable Cities: How Does the Running Environment Influence Perceived Attractiveness, Restorativeness, and Running Frequency? *Environment and Behavior*, *48*(9), 1127–1147. https://doi.org/10.1177/0013916515596364

Ewing, R., Meakins, G., Hamidi, S., & Nelson, A. C. (2014). Relationship between urban sprawl and physical activity, obesity, and morbidity – Update and refinement. *Health & Place*, *26*, 118–126. https://doi.org/10.1016/j.healthplace.2013.12.008

Griew, P., Hillsdon, M., Foster, C., Coombes, E., Jones, A., & Wilkinson, P. (2013). Developing and testing a street audit tool using Google Street View to measure environmental supportiveness for physical activity. *International Journal of Behavioral Nutrition and Physical Activity*, *10*(1), 103. https://doi.org/10.1186/1479-5868-10-103

Gullón, P., Badland, H. M., Alfayate, S., Bilal, U., Escobar, F., Cebrecos, A., Diez, J., & Franco, M. (2015). Assessing Walking and Cycling Environments in the Streets of Madrid: Comparing On-Field and Virtual Audits. *Journal of Urban Health*, *92*(5), 923–939. https://doi.org/10.1007/s11524-015-9982-z

Harden, S. R., Schuurman, N., Keller, P., & Lear, S. A. (2022). Neighborhood Characteristics Associated with Running in Metro Vancouver: A Preliminary Analysis. *International Journal of Environmental Research and Public Health*, *19*(21), 14328. https://doi.org/10.3390/ijerph192114328

Harte, J. L., & Eifert, G. H. (1995). The effects of running, environment, and attentional focus on athletes? Catecholamine and cortisol levels and mood. *Psychophysiology*, *32*(1), 49–54. https://doi.org/10.1111/j.1469-8986.1995.tb03405.x

Hitchings, R., & Latham, A. (2017). Exercise and environment: New qualitative work to link popular practice and public health. *Health & Place*, *46*, 300–306. https://doi.org/10.1016/j.healthplace.2017.04.009

Huang, D. (2022). *Analyzing the effects of nature exposure on perceived satisfaction with running routes: An activity path-based measure approach*. 10.

Inoue, Y., Funk, D., & Jordan, J. S. (2013). The Role of Running Involvement in Creating Self-Sufficiency for Homeless Individuals Through a Community-Based Running Program. *Journal of Sport Management*, *27*(6), 439–452. https://doi.org/10.1123/jsm.27.6.439

Jiang, H., Dong, L., & Qiu, B. (2022). How Are Macro-Scale and Micro-Scale Built Environments Associated with Running Activity? The Application of Strava Data and Deep Learning in Inner London. *ISPRS International Journal of Geo-Information*, *11*(10), 504. https://doi.org/10.3390/ijgi11100504

Kalak, N., Gerber, M., Kirov, R., Mikoteit, T., Yordanova, J., Pühse, U., Holsboer-Trachsler, E., & Brand, S. (2012). Daily Morning Running for 3 Weeks Improved Sleep and Psychological Functioning in Healthy Adolescents Compared With Controls. *Journal of Adolescent Health*, *51*(6), 615–622. https://doi.org/10.1016/j.jadohealth.2012.02.020

Kelly, C. M., Wilson, J. S., Baker, E. A., Miller, D. K., & Schootman, M. (2013). Using Google Street View to Audit the Built Environment: Inter-rater Reliability Results. *Annals of Behavioral Medicine*, *45*(S1), 108–112. https://doi.org/10.1007/s12160-012-9419-9

Lee, K., & Sener, I. N. (2021). Strava Metro data for bicycle monitoring: A literature review. *Transport Reviews*, *41*(1), 27–47. https://doi.org/10.1080/01441647.2020.1798558

Odgers, C. L., Caspi, A., Bates, C. J., Sampson, R. J., & Moffitt, T. E. (2012). Systematic social observation of children's neighborhoods using Google Street View: A reliable and cost-effective method: SSO in street view. *Journal of Child Psychology and Psychiatry*, *53*(10), 1009–1017. https://doi.org/10.1111/j.1469-7610.2012.02565.x

Pontin, F. (2021). Utilising smartphone data to explore spatial influences on physical activity. In M. Birkin, G. Clarke, J. Corcoran, & R. Stimson, *Big Data Applications in Geography and Planning* (pp. 79–92). Edward Elgar Publishing. https://doi.org/10.4337/9781789909791.00012

Rundle, A. G., Bader, M. D. M., Richards, C. A., Neckerman, K. M., & Teitler, J. O. (2011). Using Google Street View to Audit Neighborhood Environments. *American Journal of Preventive Medicine*, *40*(1), 94–100. https://doi.org/10.1016/j.amepre.2010.09.034

Runner Friendly Community Designation®. (2021). Road Runners Club of America. Retrieved 8 January 2023, from https://www.rrca.org/programs/runner-friendly-community/

Schuurman, N., Rosenkrantz, L., & Lear, S. A. (2021). Environmental Preferences and Concerns of Recreational Road Runners. *International Journal of Environmental Research and Public Health*, *18*(12), 6268. https://doi.org/10.3390/ijerph18126268

Shashank, A., Schuurman, N., Copley, R., & Lear, S. (2022). Creation of a rough runnability index using an affordance-based framework. *Environment and Planning B: Urban Analytics and City Science*, *49*(1), 321–334. https://doi.org/10.1177/23998083211003886

Sun, Y. (2017). Exploring potential of crowdsourced geographic information in studies of active travel and health: Strava data and cycling behaviour. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *XLII-2/W7*, 1357–1361. https://doi.org/10.5194/isprs-archives-XLII-2-W7-1357-2017

Taylor, B. T., Fernando, P., Bauman, A. E., Williamson, A., Craig, J. C., & Redman, S. (2011). Measuring the Quality of Public Open Space Using Google Earth. *American Journal of Preventive Medicine*, *40*(2), 105–112. https://doi.org/10.1016/j.amepre.2010.10.024

Villanueva, K., Pereira, G., Knuiman, M., Bull, F., Wood, L., Christian, H., Foster, S., Boruff, B. J., Beesley, B., Hickey, S., Joyce, S., Nathan, A., Saarloos, D., & Giles-Corti, B. (2013). The impact of the built environment on health across the life course: Design of a cross-sectional data linkage study. *BMJ Open*, *3*(1), e002482. https://doi.org/10.1136/bmjopen-2012-002482

Wu, Y.-T., Nash, P., Barnes, L. E., Minett, T., Matthews, F. E., Jones, A., & Brayne, C. (2014). Assessing environmental features related to mental health: A reliability study of visual streetscape images. *BMC Public Health*, *14*(1), 1094. https://doi.org/10.1186/1471-2458-14-1094

Yang, L., Yu, B., Liang, P., Tang, X., & Li, J. (2022). Crowdsourced Data for Physical Activity-Built Environment Research: Applying Strava Data in Chengdu, China. *Frontiers in Public Health*, *10*, 883177. https://doi.org/10.3389/fpubh.2022.883177