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Estimating children's Active School Travel behaviour using the ROute Observation for Travelling to School (ROOTS) instrument

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ABSTRACT

Introduction: Active School Travel (AST) programs, such as Safe Routes to School (SR2S), have been predominantly evaluated using self-reported methods that are susceptible to bias (e.g., social desirability). Objective methods, such as observational route counts, are underutilised in AST program evaluations, and existing studies have not assessed instrument inter-rater reliability. This study aimed to strengthen the evidence base supporting the use of objective measurements to estimate school children's AST behaviour by adapting an existing observational route counting instrument to align with the route-level aims of SR2S programs and assessing its inter-rater reliability.
Methods: The ROute Observation for Travelling to School (ROOTS) instrument was adapted from Crawford and Gerrard's Ride2School instrument. Reliability data were collected across four days from three purposively selected public primary schools (one school per day with one school repeated due to rain). Four pairs of trained observers were assigned to different routes at observation points approximately 100–200m away from the same school on the same day. Without conferring, the observational pairs recorded all active travel behaviour (i.e., children walking, cycling, scootering, skating to school), for four 15-minute intervals between 8:15am and 9:15am. Intraclass Correlation Coefficients (ICC) were computed to assess the inter-rater reliability of each observational pair.
Results: The total number of observations made by the four observational pairs was 353.0 (M = 88.3, SD = 27.1). ICCs for observational pairs ranged between 0.841 (95% CI: 0.758, 0.897) and 1.000, reflecting good to excellent inter-rater reliability.
Conclusion: The ROOTS instrument had good to excellent inter-rater reliability, which supports the use of observational route counts to provide AST evaluations with an objective, reliable alternative to self-reported methods. The ROOTS instrument may be particularly useful for researchers and practitioners evaluating route-level AST behaviour in SR2S programs to tailor these programs to the route-level needs of children and parents.

1. Introduction

It is well established that physical inactivity is a significant risk factor for the development of childhood obesity (World Health

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List of abbreviations

AST – Active School Travel
ICC – Intraclass Correlation Coefficient
ROOTS – ROute Observation for Travelling to School
SR2S – Safe Routes to School

Organisation, 2004). It is recommended that children aged 5–17 achieve 60 minutes of moderate to vigorous physical activity per day, and muscle and bone strengthening activities three times per week (World Health Organisation, 2010). However, an international study that analysed physical activity data across 49 countries found that approximately 70 percent of children and youth do not meet this recommendation (Aubert et al., 2018).

AST, such as walking, cycling, scootering, or skating to school, has been identified as a practical way for children to integrate moderate to vigorous physical activity into their daily routines. Some studies have found AST to be associated with a variety of physical health benefits, such as increased physical activity (van Sluijs et al., 2009; Denstel et al., 2015; Larouche et al., 2014a), improved cardiovascular fitness (Larouche et al., 2014a), and healthier body composition (Larouche et al., 2014a; Lubans et al., 2011). While not all studies assessing AST have observed specific health benefits (Larouche et al., 2011, 2014a; Roth et al., 2012), AST is widely considered a useful strategy enabling regular physical activity.

Despite its benefits, significant declines in AST have been seen across many developed countries, with a cultural shift towards more passive modes of travel (Fyhri et al., 2011; Tremblay et al., 2014). The factors influencing the declines in AST are multifaceted, and operate across multiple domains (e.g., intrapersonal, interpersonal, institutional, community, and public policy) (Ikeda et al., 2018, 2019). However, travel distance between home and school and parental perceptions of the safety of the built and social environments have been identified as among the most influential (Lu et al., 2014; Aranda-Balboa et al., 2020).

In efforts to address parental safety concerns and increase the number of children engaged in AST, programs such as SR2S have been introduced in countries including Australia (We Ride Australia, 2018), Canada (City Government of Toronto, 2018), and the United States (US Department of Transportation, 2015). SR2S programs aim to promote safer environments for children to actively travel to school. A major component of these programs is the school specific SR2S map, which highlights identified 'safe' routes that avoid main roads and minimise road crossings (Safe Routes Partnership, 2013). SR2S programs have been associated with increases in school-level walking and cycling, and reductions in school-aged injury and fatality risk (McDonald et al., 2014; Buttazzoni et al., 2018; DiMaggio et al., 2016). However, despite these programs promoting the use of designated routes to school, no published studies to date have evaluated AST behaviour change at the actual route level. Studies conducted thus far have instead opted to investigate school-level changes, which does not capture variations in route-level traffic flow.

Evaluations of AST programs, including SR2S, have commonly applied self-reported methods, such as parent and child surveys, to subjectively assess AST behaviour (Larouche et al., 2018; Jones et al., 2019). Although independent assessments of the reliability of these methods have shown substantial levels of agreement between parent and child reports (Evenson et al., 2008), this level of agreement has not always extended into the evaluation of AST programs. A number of AST evaluations have reported inconsistencies between child and parent reported AST behaviour (Wen et al., 2008; Crawford and Garrard, 2013), which can consequently lead to different interpretations of an intervention's outcome. Some of the issues encountered with self-reported methods, such as response, recall, or social desirability biases, can have a significant impact on the validity of the data collected (Larouche et al., 2014b). The impact of these biases could be avoided by using objective methods. However, few evaluation studies have made use of objective approaches (Larouche et al., 2018; Jones et al., 2019). In their 2018 systematic review, Larouche et al. (2018) found that, from the 27 included AST program evaluations, only 7 used objective methods to assess AST behaviour, while the remaining 20 used self-reported methods.

Observational route counts are one objective method that has been used in AST program evaluations. Observational route counts have a number of advantages over other forms of objective methods (e.g., accelerometers). For example, they are not susceptible to participant error (e.g., participants not wearing the accelerometer (McMinn et al., 2012)), and they support the capture of data on travel group composition. Studies from Australia (Crawford and Garrard, 2013), Canada (Rothman et al., 2014, 2016), and the United States (Bungum et al., 2014; Buckley et al., 2013) have used observational route counts to assess AST behaviour. However, a number of these studies did not assess the reliability of the instrument used (Crawford and Garrard, 2013; Bungum et al., 2014; Buckley et al., 2013), and where instrument reliability was assessed, the authors provide insufficient detail on how the reliability data was collected and how the test-retest reliability was assessed (Rothman et al., 2014). These unknown levels of reliability and ambiguous reports of reliability raise concern about the overall validity of the data collected in these studies, as well as the utility of these instruments for future AST evaluations using observational route counts. Moreover, the current observational route counting instruments available to researchers and practitioners were all designed with the intention of collecting school-level estimates of AST behaviour. Thus, these instruments are not suitable for conducting route-level counts when factors such as school co-location (i.e., when two schools are close to each other) can compromise the accuracy of the data collected.

A reliable observational instrument to assess AST behaviour would support the use of objective methods versus potentially biased subjective methods to evaluate the outcomes of AST programs. Additionally, within the context of SR2S programs, a reliable instrument designed to capture route-specific counts would also provide an understanding of variations in student traffic flow between a school's designated safe routes. Thus, this study aimed to strengthen the evidence base supporting the use of objective measurements to estimate school children's AST behaviour by: 1) adapting an existing instrument for conducting observational route-level counts of children's AST behaviour to align more strongly with the aims of SR2S programs and children's AST programs more broadly; and 2) assessing the adapted instrument's inter-rater reliability.

2. Materials & methods

2.1. Research context

This study was conducted within the context of the 2018–2022 Active Streets for Schools program, an Australian Capital Territory government funded SR2S program. The program was designed to encourage children of primary school age to engage in regular AST behaviour. Twenty-three public primary schools are enrolled in the program. The program utilises a multi-component design, through educational resources, school specific SR2S maps, wayfinding stencils, and targeted infrastructure changes, to address established barriers towards AST.

2.2. Instrument adaptation

The ROOTS instrument was adapted from an observational route counting instrument identified from a review of the AST literature. Crawford and Gerrard (2013) developed the Ride2School instrument to evaluate the Ride2School program in Victoria, Australia. The Ride2School instrument has two distinctive features: 1) a combination style counting format to represent the composition of travel groups (e.g., ABGG circled would represent one adult ['A'] accompanying one boy ['B'] and two girls ['GG']); and 2) the codes are tabulated into one of three columns to designate mode of travel (i.e., walking, cycling or other). As the aims of the Ride2School program were cycling focused, the instrument was designed to collect data on cycling specific behaviour, and thus differentiated cycling from other modes of wheeled and non-wheeled transport. However, many AST programs, such as SR2S programs, are not focused on promoting a specific mode of active travel, and instead aim to promote active travel through multiple modes such as walking, cycling, scootering, and skating. Additionally, the instrument did not differentiate between children from different schools (e.g., a target school vs a non-target school), which is important for the accuracy of data collected when conducting observational route counts in co-located school contexts. Thus, the ROOTS instrument was adapted to align more strongly with the broader aims of children's AST programs. The adaptation of the ROOTS instrument for use in the evaluation of SR2S programs occurred in two stages, outlined below.

In the first stage of the adaptation process, the aims of SR2S programs were reviewed to determine the parameters to include in the ROOTS instrument. Typically, AST programs aim to promote children's active travel, whether wheeled or walking, and accompanied or unaccompanied by adults, siblings, or friends. Thus, a suitable observational route counting instrument would be required, at a minimum, to:

(1) Identify wheeled/unwheeled active travellers;
(2) Identify accompanied/unaccompanied active travellers;
(3) Distinguish between active travellers from a target intervention school and non-target schools; and
(4) Be flexible enough for observers to be allocated at different distances from the school to accommodate variation in definitions of what constitutes an active trip (e.g., Australian 10-minute definition of an active trip) and research/evaluation needs.

In the second stage, the adapted instrument was field tested to refine its usability. Two members of the research team (TVV/MC) applied the instrument at a local primary school. Both researchers observed children's active travel behaviour from the same location, approximately 100–200m away from the school. As the development process was iterative in nature, several field tests were performed. At the conclusion of each instrument field test, the two researchers met to discuss their experience of using the instrument (e.g., how could the interface be simplified for the user), any issues and/or challenges encountered while conducting the field tests (e.g., how to code children using mobility aids), and general comments on conducting the field tests (e.g., optimal observation point locations). Following these discussions, several refinements were made. Examples of refinements include: 1) to advise observers in the training to place a vertical line after each code combination to clearly separate codes to avoid confusion; 2) coding mobility aid users

Table 1
Codes used for the ROOTS instrument.

Code	Meaning
T	Target school child
T̲	Target school child wheeled
Nt	Non-target school child
N̲t̲	Non-target school child wheeled
A	Adult
A̲	Adult wheeled
○	Child(ren) accompanied by an adult
□	Children travelling in a group or with sibling(s)

within the standard coding structure and using the notes section to capture specific detail on the mobility aid used; and 3) placing a 50m buffer around the observation point to allow observers to move location to ensure optimal visibility of the route and observer comfort (e.g., shade). Amendments were presented to the remaining members of the research team (SJC/MD) and refined until all members agreed upon the final instrument.

The final iteration of the ROOTS instrument (see supplementary data file A) uses a combination style format consisting of three core codes: a child from a target school (i.e., T), a non-target school child (i.e., Nt), and an adult (i.e., A). School uniform items and colours are used to distinguish between children from target and non-target schools. A summary of the codes supporting the instrument are provided in Table 1. To collect data for travel group composition, individual codes are combined to form a single code. For example, a code of AT circled would represent one adult accompanying one target school child, both walking. To collect data for mode of travel, codes are underlined to differentiate between walking and wheeled active travellers. For example, T would represent a child from the target school travelling unaccompanied using wheeled transport.

2.3. Sampling

For the assessment of instrument reliability, three public primary schools enrolled on the Active Streets for Schools program were purposively selected. The three schools were selected based upon their varying contexts to allow reliability to be tested under different contextual conditions. The three purposively selected schools and their contexts for selection can be seen in Table 2. School A was selected as it was a primary school and had a medium-sized student population (i.e., between 300 and 600 students), allowing for testing under conditions with intermittent pedestrian traffic flows. School B was selected as it was a primary school and had a large student population (i.e., over 600 students), with expectations of high pedestrian traffic flows. School C was selected as it was a primary school and was located proximal to another primary school, where observers were required to differentiate active travellers from a target intervention school and a non-target school.

2.4. Data collection

2.4.1. Training of observers

A team of observers conducted the instrument reliability assessment. As all three purposively selected schools had four SR2S each, the data collection team for the instrument reliability assessment consisted of eight observers (four inter-rater reliability assessment pairings). The team consisted of students (i.e., Undergraduate, Masters and PhD) and university research staff. Prior to reliability data being collected, all observers participated in a two-part training session in February 2020. Training was delivered in two segments by the lead author. In the first segment, observers participated in a 1-hour classroom-based session. An overview of the instrument was provided so that observers had the opportunity to test their knowledge of the instrument through scenario-based coding exercises using PowerPoint. The second segment of the training was a 90-minute, in-field practical exercise to provide observers with experience applying the instrument. Upon completion of each training session, observers were prompted to raise questions they had about the instrument or their role. All observers reported being comfortable with the instrument after the two-part training session.

2.4.2. Count data to assess reliability

The instrument reliability observations were conducted in March 2020. Data were initially collected over three days of the same week (i.e., Tuesday, Wednesday, and Thursday) at a different school each day. The eight observers (four pairs, one pair per route) all attended the same designated school on the same day. Multiple pairs of observers have been used in a previous study protocol to assess the inter-rater reliability of an observational instrument for assessing characteristics of parks for adults' and children's physical activity (Bedimo-Rung et al., 2006). Observation points were assigned 100–200m away from the school to maximise the number of route-level observations made by the observational pairs.

All observers were provided with an observation point package prior to the reliability counts being conducted. This package was developed in conjunction with the ROOTS instrument to assist the observer to find the assigned observation point location and identify target school uniforms (see supplementary data file B). The package contained latitude and longitude co-ordinates and satellite images to identify the observation point location, a uniform summary table listing uniform items, colours, and images (from publicly available data), and latitude and longitude co-ordinates for a debrief location.

The observational route counts were conducted over a 60-minute period (8:15am to 9:15am), to coincide with a school start time of 9:00am. Count data were recorded in 15-minute intervals. Although there were no external advisors present to supervise the observational pairs during the data collection, observers situated themselves at assigned observation points so that each observer's recordings were not visible to their paired observer. Observers also did not confer during the data collection period. Upon conclusion of the day's observational route counting, all observers met on site at the assigned debrief location to share experiences, raise any issues

Table 2
Sampled schools for inter-rater reliability assessment.

School	Student Population	Selection Context	Number of SR2S
A	491	Medium school population	4
B	876	Large student population	4
C	533	Co-located with another primary school	4

encountered, ask questions, and provide their data sheet(s) to the lead author.

Due to significant rainfall on days two and three (i.e., Wednesday/Thursday), which resulted in a low number of observations, data collection for school C was repeated on a fourth day (a Monday). An equivalent strategy was not possible for school B, due to school closures in response to the COVID-19 outbreak. The repeated observational route counts for school C were conducted in the afternoon, between 3:00pm and 3:45pm, due to observer availability.

This research was performed in compliance with all applicable laws and institutional guidelines. Ethical approval was obtained from the University of Canberra's Human Research Ethics Committee (reference: 20192067).

2.5. Data analysis

Daily inter-rater reliability was assessed by computing the ICC for each pair of observers. ICC estimates and their 95% confidence intervals were based on a single-rating, absolute-agreement, 2-way random effects model (Koo and Li, 2016). All analysis was performed in IBM Statistical Package for the Social Science (SPSS) v.25 (IBM, 2019). In accordance with the ICC reporting guidelines, values < 0.5 were considered to reflect poor inter-rater reliability, ≥ 0.5 to <0.75 moderate reliability, ≥ 0.75 to <0.9 good reliability, and values ≥ 0.9 excellent reliability (Koo and Li, 2016).

3. Results

Daily observation counts are displayed in Table 3. The total number of observations made by the four observational pairs across the four data collection days was 353.0 (M = 88.3, SD = 27.1). There was large variation in counts across the four days. On days two and three (when it rained), there were considerably fewer observations made by all the observation pairs. All pairs made more observations when counting was conducted in the afternoon.

Inter-rater reliability results are displayed in Table 4. The ICCs for daily paired observations ranged from 0.841 (95% CI: 0.758, 0.897) to 1.000 reflecting good to excellent inter-rater reliability. The greatest variation in ICCs was observed on day four (between 0.841 (95% CI: 0.758, 0.897) and 0.920 (95% CI: 0.876, 0.949)). However, the level of agreement between all pairs remained within the good to excellent range.

4. Discussion

AST programs aim to promote children's engagement in AST behaviour by making active travel a safe alternative to passive modes of travel. However, few objective measures are available to generate reliable estimates of AST behaviour, particularly at the route level. To strengthen the evidence supporting the use of observational route counts as an objective method of assessing children's AST behaviour within AST programs broadly, and SR2S programs more specifically, an observational route counting instrument was adapted from an existing instrument and assessed for inter-rater reliability. The current study found good to excellent inter-rater reliability (between 0.841 and 1.000) for the ROOTS instrument for conducting observational route counts across varying school contexts. On days where the observational pairs made a greater number of observations, the inter-rater reliability was subject to greater variation. However, the level of agreement between the pairs remained within the good to excellent range.

Thus far, only one study has reported on a reliability analysis utilising an observational route count instrument to assess AST behaviour. Rothman et al. (2014) reported high test-retest reliability (Pearson's r = 0.96) for their observational route counting instrument using observational counts conducted one week apart. Use of the test-retest design to assess the reliability of such an instrument may be inappropriate, however, as the purpose of test-retest reliability is to assess the consistency of data collected over time. This may be challenging for AST, as significant variation in daily AST behaviour can occur, as illustrated in our descriptive results (Table 3). Moreover, observational route counts of a single school may require a team of observers to assess multiple routes or multiple school entrances. Several studies have used multiple observers to collect data without assessing whether the observational route counting instrument applied was reliable between observers (Crawford and Garrard, 2013; Rothman et al., 2014; Bungum et al., 2014; Buckley et al., 2013). Thus, the assessment of inter-rater reliability for an objective observational route counting instrument is important to support the use of objective methods. As shown in this study, the ROOTS instrument displayed a high level of inter-rater reliability and, therefore, should be considered for use in future AST evaluations using observational route counts to assess AST behaviour.

Table 3
Number of reliability observations made by each observer by reliability data collection day.

	Day 1		Day 2		Day 3		Day 4		Total	Mean	SD
	Obs1	Obs2	Obs1	Obs2	Obs1	Obs2	Obs1	Obs2			
Pair 1	19	19	4	4	8	8	24[a]	21[a]	107.0	13.4	7.6
Pair 2	10	10	5	5	2	2	11[a]	11[a]	56.0	7.0	3.7
Pair 3	6	6	3	3	8	8	20[a]	22[a]	76.0	9.5	6.9
Pair 4	29[a]	31[a]	3	3	1	1	22[a]	24[a]	114.0	14.3	12.5

N.B Values refer to codes of travellers, not the count of individual travellers (e.g. An Adult and two children counted as one code).

[a] Observations conducted in the afternoon due to observer availability.

Table 4
Results of ICC calculation using single-rating, absolute-agreement, 2-way random effects model.

		Intraclass Correlation	95% Confidence Interval		F Test with True Value 0			
		Single Measurement	Lower bound	Upper Bound	Value	df_1	df_2	p-value
Day 1	Pair 1	1.000	–	–	–	73	–	–
	Pair 2	1.000	–	–	–	73	–	–
	Pair 3	1.000	–	–	–	73	–	–
	Pair 4	0.976	0.962	0.985	80.981	73	73	<0.0001
Day 2	Pair 1	1.000	–	–	–	73	–	–
	Pair 2	1.000	–	–	–	73	–	–
	Pair 3	1.000	–	–	–	73	–	–
	Pair 4	1.000	–	–	–	73	–	–
Day 3	Pair 1	1.000	–	–	–	73	–	–
	Pair 2	1.000	–	–	–	73	–	–
	Pair 3	1.000	–	–	–	73	–	–
	Pair 4	1.000	–	–	–	73	–	–
Day 4	Pair 1	0.915	0.868	0.945	22.290	73	73	<0.0001
	Pair 2	0.920	0.876	0.949	23.730	73	73	<0.0001
	Pair 3	0.841	0.758	0.897	11.439	73	73	<0.0001
	Pair 4	0.872	0.805	0.918	14.512	73	73	<0.0001

The ROOTS instrument was not designed to collect information on the gender of active travellers, a departure from earlier instruments (Rothman et al., 2014; Bungum et al., 2014; Buckley et al., 2013) and, more specifically, from the Ride2School instrument developed by Crawford & Gerrard (Crawford and Garrard, 2013). The substitution of target and non-target school codes for the previous gendered codes was done to simplify the instrument, to prioritise the accuracy of the observations made in challenging school contexts. Specific challenges include schools with high pedestrian traffic flow and those where observers would be required to differentiate students based on the uniform worn, given co-location of a school with one or more other schools. Importantly, the challenges associated with school co-location, such as impact on the accuracy of observational counts, have not been raised in any previous evaluations (Crawford and Garrard, 2013; Rothman et al., 2014; Bungum et al., 2014; Buckley et al., 2013). This may be due to observations being made at the school gate, selection solely of isolated schools, or international environmental and school policy contexts differing to those of Australia. The reliability of the ROOTS instrument was, therefore, specifically tested within a co-located school context. The ROOTS instrument, the training, and the specificity of the accompanying resource materials allowed for the reliable collection of observational route count data within this real-world context. Furthermore, the application of target and non-target school codes used on the ROOTS instrument showed sufficient flexibility to permit observational route counts to be conducted at different distances from the school. This makes the ROOTS instrument particularly applicable to observational route counting in countries where active travel definitions have a trip length or duration component. For example, in Australia, an active trip is required to be a minimum of 10 minutes in duration either to or from school.

Previous studies that have utilised observational route counts to evaluate AST programs have neglected to investigate changes in AST behaviour at the route level. These studies have instead opted to use aggregated counts from different locations, notably school gates, to form a school-level estimate of AST behaviour (Crawford and Garrard, 2013; Rothman et al., 2014; Bungum et al., 2014; Buckley et al., 2013). The aggregated counts may be a consequence of observers being positioned too close to the school to distinguish route-level activity or there being no reliable instrument that enables the collection of route-level counts to be conducted away from the school gate. There may also be a perceived lack of utility of route-level counts in AST evaluations. However, the collection of route-level AST behaviour data, particularly within SR2S programs, can provide utility in AST program evaluations by providing researchers and practitioners with insight into route-level activity (e.g., which routes are more popular). The ROOTS instrument was specifically designed to allow for the collection of route-level data, which can be particularly useful to inform interviews and other participatory methods (e.g., comprehensive mapping sessions) with children and parents so researchers and practitioners can understand the route-level contextual factors that might influence AST behaviour (Mandic et al., 2020). For example, a route may be deemed safe from an objective transport perspective, however, a social element along a route (e.g., congregating teenagers) might impact parental perceived safety, resulting in that route not being used.

The resources required to conduct observational route counts in the evaluation of AST programs has been raised as an issue of concern. (Crawford and Garrard, 2013). This small-scale study, which used eight observers, one 2.5-hour training session, and 32 labour hours (i.e., total time required for all eight staff to conduct the data collection), was not deemed resource intensive. However, it is acknowledged that using observational route counts in larger-scale AST evaluations may require greater resources. The number of observers required will be dependent on the number of schools participating, the number of independent routes that need to be observed, and/or the timeframe for conducting the data collection (i.e., shorter timeframe may be associated with greater resource demand). Moreover, it may be more logistically feasible to use observational route counts in AST evaluations that use designs with a single or small sample of schools. In these evaluations, observational route counts can be used to measure changes in the AST behaviour of a specific route over time or measure pre-post changes in the AST behaviour of a specific route in relation to a new environmental infrastructure change (e.g., new crossing facilities).

The ROOTS instrument has important relevance and advantages for researchers and practitioners. The instrument provides those conducting AST program evaluations with a reliable and versatile alternative to self-reported methods. The route-level focus of the ROOTS instrument can inform qualitative elements of evaluations that can provide insight into the route-level contextual factors that promote and inhibit AST behaviour. This understanding can be useful for enabling researchers and practitioners to develop and tailor all AST programs, but particularly SR2S, to the route-level needs of children and parents. Building on the work of Ross and Buliung (2018), there is a need for future research to investigate how AST programs and their evaluations can better engage disabled children, who may view and experience AST and AST programs differently to children living without disability. In the context of SR2S programs, it is important for researchers and practitioners to ensure SR2S programs promote routes to school that are accessible for children with disabilities.

This study had several strengths. It is, to our knowledge, the first study to assess the inter-rater reliability of an observational route counting instrument for estimating children's AST behaviour. It builds on and expands other work supporting the use of observational route counts as an evaluation method, and supplements other objective methods available to researchers and practitioners conducting AST research and evaluation. The data used in the reliability analysis for the ROOTS instrument were collected in three purposively selected school contexts, demonstrating the versatility and reliability of the instrument within real world school contexts that researchers and practitioners may encounter when evaluating AST programs. The ROOTS instrument was able to generate reliable counts of AST behaviour with minimal training, using observers with minimal research experience and background. This suggests that the ROOTS instrument is easy to use.

This study and the ROOTS instrument are not without limitations. Due to significant rainfall on data collection days two and three, only a small number of observations were made for schools B and C. Although observations for school C were repeated on a fourth day, this was not possible for school B due to school closures in response to the COVID-19 outbreak. However, as a high number of observations were made during the fourth day of data collection with the inter-rater reliability found to be within the good to excellent range, this was considered a sufficient test of the ROOTS instrument reliability in a school context with high pedestrian traffic flow. As the ROOTS instrument relies on school uniform to differentiate between active travellers from co-located target and non-target schools, applying the instrument to assess AST behaviour in regions where school uniforms are not mandatory may be challenging. As noted, the ROOTS instrument does not capture the gender of active travellers.

5. Conclusions

Observational route counts as an objective method of assessing AST behaviour in program evaluations are underutilised, particularly in SR2S programs that promote active children's travel along designated routes. This circumstance may reflect, in part, the absence of a reliable observational instrument. The ROOTS instrument demonstrated good to excellent inter-rater reliability for conducting observational route counts to assess children's AST behaviour. The ROOTS instrument strengthens the evidence base supporting the use of objective measurements by providing researchers and practitioners conducting evaluations of AST programs with a reliable alternative to self-reported methods. The instrument may be particularly useful for researchers and practitioners evaluating route-level AST behaviour in SR2S programs to tailor these programs to the route-level needs of children and parents.

CRediT authorship statement

Thomas V. Vasey: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing - Original Draft, Project Administration. Suzanne J. Carroll: Conceptualization, Methodology, Formal Analysis, Writing – Review & Editing, Supervision. Mark Daniel: Conceptualization, Methodology, Formal Analysis, Writing – Review & Editing, Supervision. Margaret Cargo: Conceptualization, Methodology, Investigation, Formal Analysis, Writing – Review & Editing, Supervision, Project Administration.

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Declaration of competing interest

The authors declare no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jth.2021.101287.

References

Aranda-Balboa, M.J., Huertas-Delgado, F.J., Herrador-Colmenero, M., Cardon, G., Chillón, P., 2020. Parental barriers to active transport to school: a systematic review. Int. J. Publ. Health. https://doi.org/10.1007/s00038-019-01313-1.

Aubert, S., Barnes, J.D., Abdeta, C., Abi Nader, P., Adeniyi, A.F., Aguilar-Farias, N., et al., 2018. Global matrix 3.0 physical activity report card grades for children and youth: results and analysis from 49 countries. J. Phys. Activ. Health. https://doi.org/10.1123/jpah.2018-0472.

Bedimo-Rung, A.L., Gustat, J., Tompkins, B.J., Rice, J., Thomson, J., 2006. Development of a direct observation instrument to measure environmental characteristics of parks for physical activity. J. Phys. Activ. Health. https://doi.org/10.1123/jpah.3.s1.s176.

Buckley, A., Lowry, M.B., Brown, H., Barton, B., 2013. Evaluating safe routes to school events that designate days for walking and bicycling. Transport Pol. https://doi.org/10.1016/j.tranpol.2013.09.021.

Bungum, T.J., Clark, S., Aguilar, B., 2014. The effect of an active transport to school intervention at a suburban elementary school. Am. J. Health Educ. https://doi.org/10.1080/19325037.2014.916635.

Buttazzoni, A.N., Van Kesteren, E.S., Shah, T.I., Gilliland, J.A., 2018. Active school travel intervention methodologies in North America: a systematic review. Am. J. Prev. Med. https://doi.org/10.1016/j.amepre.2018.04.007.

City Government of Toronto, 2018. Active & Safe Routes to School Pilot. https://www.toronto.ca/services-payments/streets-parking-transportation/road-safety/vision-zero/safety-initiatives/active-and-safe-routes-to-school-pilot/. (Accessed 7 June 2021).

Crawford, S., Garrard, J., 2013. A combined impact-process evaluation of a program promoting active transport to school: understanding the factors that shaped program effectiveness. J. Environ. Publ. Health. https://doi.org/10.1155/2013/816961.

Denstel, K.D., Broyles, S.T., Larouche, R., Sarmiento, O.L., Barreira, T.V., Chaput, J.-P., et al., 2015. Active school transport and weekday physical activity in 9-11-year-old children from 12 countries. Int. J. Obes. Suppl. https://doi.org/10.1038/ijosup.2015.26.

DiMaggio, C., Frangos, S., Li, G., 2016. National safe routes to school program and risk of school-age pedestrian and bicyclist injury. Ann. Epidemiol. https://doi.org/10.1016/j.annepidem.2016.04.002.

Evenson, K.R., Neelon, B., Ball, S.C., Vaughn, A., Ward, D.S., 2008. Validity and reliability of a school travel survey. J. Phys. Activ. Health. https://doi.org/10.1123/jpah.5.s1.s1.

Fyhri, A., Hjorthol, R., Mackett, R.L., Fotel, T.N., Kyttä, M., 2011. Children's active travel and independent mobility in four countries: development, social contributing trends and measures. Transport Pol. https://doi.org/10.1016/j.tranpol.2011.01.005.

IBM, 2019. Statistical Package for the Social Sciences (SPSS) Version 25.

Ikeda, E., Hinckson, E., Witten, K., Smith, M., 2018. Associations of children's active school travel with perceptions of the physical environment and characteristics of the social environment: A systematic review. Health Place. https://doi.org/10.1016/j.healthplace.2018.09.009.

Ikeda, E., Hinckson, E., Witten, K., Smith, M., 2019. Assessment of direct and indirect associations between children active school travel and environmental, household and child factors using structural equation modelling. Int. J. Behav. Nutr. Phys. Activ. https://doi.org/10.1186/s12966-019-0794-5.

Jones, R.A., Blackburn, N.E., Woods, C., Byrne, M., van Nassau, F., Tully, M.A., 2019. Interventions promoting active transport to school in children: a systematic review and meta-analysis. Prev. Med. https://doi.org/10.1016/j.ypmed.2019.03.030.

Koo, T.K., Li, M.Y., 2016. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J. Chiropr. Med. https://doi.org/10.1016/j.jcm.2016.02.012.

Larouche, R., Lloyd, M., Knight, E., Tremblay, M.S., 2011. Relationship between active school transport and body mass index in grades-4-to-6 children. Pediatr. Exerc. Sci. https://doi.org/10.1123/pes.23.3.322.

Larouche, R., Saunders, T.J., Faulkner, G.E.J., Colley, R., Tremblay, M., 2014a. Associations between active school transport and physical activity, body composition, and cardiovascular fitness: a systematic review of 68 studies. J. Phys. Activ. Health. https://doi.org/10.1123/jpah.2011-0345.

Larouche, R., Oyeyemi, A.L., Prista, A., Onywera, V., Akinroye, K.K., Tremblay, M.S., 2014b. A systematic review of active transportation research in Africa and the psychometric properties of measurement tools for children and youth. Int. J. Behav. Nutr. Phys. Activ. https://doi.org/10.1186/s12966-014-0129-5.

Larouche, R., Mammen, G., Rowe, D.A., Faulkner, G., 2018. Effectiveness of active school transport interventions: a systematic review and update. BMC Publ. Health. https://doi.org/10.1186/s12889-017-5005-1.

Lu, W., McKyer, E.L.J., Lee, C., Goodson, P., Ory, M.G., Wang, S., 2014. Perceived barriers to children's active commuting to school: a systematic review of empirical, methodological and theoretical evidence. Int. J. Behav. Nutr. Phys. Activ. https://doi.org/10.1186/s12966-014-0140-x.

Lubans, D.R., Boreham, C.A., Kelly, P., Foster, C.E., 2011. The relationship between active travel to school and health-related fitness in children and adolescents: a systematic review. Int. J. Behav. Nutr. Phys. Activ. https://doi.org/10.1186/1479-5868-8-5.

Mandic, S., Hopkins, D., García Bengoechea, E., Moore, A., Sandretto, S., Coppell, K., et al., 2020. Built environment changes and active transport to school among adolescents: BEATS Natural Experiment Study protocol. BMJ Open. https://doi.org/10.1136/bmjopen-2019-034899.

McDonald, N.C., Steiner, R.L., Lee, C., Rhoulac Smith, T., Zhu, X., Yang, Y., 2014. Impact of the safe routes to school program on walking and bicycling. J. Am. Plann. Assoc. https://doi.org/10.1080/01944363.2014.956654.

McMinn, D., Rowe, D.A., Murtagh, S., Nelson, N.M., 2012. The effect of a school-based active commuting intervention on children's commuting physical activity and daily physical activity. Prev. Med. https://doi.org/10.1016/j.ypmed.2012.02.013.

Ross, T., Buliung, R., 2018. A systematic review of disability's treatment in the active school travel and children's independent mobility literatures. Transport Rev. https://doi.org/10.1080/01441647.2017.1340358.

Roth, M.A., Millett, C.J., Mindell, J.S., 2012. The contribution of active travel (walking and cycling) in children to overall physical activity levels: a national cross sectional study. Prev. Med. https://doi.org/10.1016/j.ypmed.2011.12.004.

Rothman, L., To, T., Buliung, R., Macarthur, C., Howard, A., 2014. Influence of social and built environment features on children walking to school: an observational study. Prev. Med. https://doi.org/10.1016/j.ypmed.2013.12.005.

Rothman, L., Macpherson, A.K., Howard, A., Parkin, P.C., Richmond, S.A., Birken, C.S., 2016. Direct observations of active school transportation and stroller use in kindergarten children. Prev. Med. Rep. https://doi.org/10.1016/j.pmedr.2016.10.009.

Safe Routes Partnership, 2013. The 6 E's of Safe Routes to School. https://www.saferoutespartnership.org/safe-routes-school/101/6-. (Accessed 15 April 2021).

Tremblay, M.S., Gray, C.E., Akinroye, K., Harrington, D.M., Katzmarzyk, P.T., Lambert, E.V., et al., 2014. Physical activity of children: a global matrix of grades comparing 15 countries. J. Phys. Activ. Health. https://doi.org/10.1123/jpah.2014-0177.

US Department of Transportation, 2015. Safe Routes to School Programs. Transportation and Health. https://www.transportation.gov/mission/health/Safe-Routes-to-School-Programs. (Accessed 3 June 2021).

van Sluijs, E.M.F., Fearne, V.A., Mattocks, C., Riddoch, C., Griffin, S.J., Ness, A., 2009. The contribution of active travel to children's physical activity levels: cross-sectional results from the ALSPAC Study. Prev. Med. https://doi.org/10.1016/j.ypmed.2009.03.002.

We Ride Australia, 2018. Towards Safe Routes to School. https://www.weride.org.au/towards-saferoutestoschool/. (Accessed 7 June 2021).

Wen, L.M., Fry, D., Merom, D., Rissel, C., Dirkis, H., Balafas, A., 2008. Increasing active travel to school: are we on the right track? A cluster randomised controlled trial from Sydney, Australia. Prev. Med. https://doi.org/10.1016/j.ypmed.2008.09.002.
World Health Organisation, 2004. Global Strategy on Diet, Physical Activity and Health. https://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf. (Accessed 24 March 2021).
World Health Organisation, 2010. Global Recommendations on Physical Activity for Health. https://www.who.int/publications/i/item/9789241599979. (Accessed 25 March 2021).