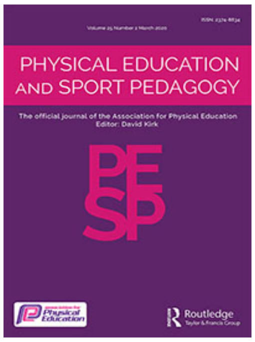

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Development and reliability of the KIM cycling scale – a measurement tool for the development process to cycling independently

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ABSTRACT

Background: Cycling has gained more attention as an important lifelong physical activity. Learning to cycle independently without assistance is a milestone for most children that requires time and practice to master. Cycling was recently added to the motor development model and so a valid and reliable measure of cycling ability is required to allow accurate assessment of the skill. Cycling has many health benefits along with being a commonly reported physical activity globally and therefore is an important skill to promote in early childhood and throughout life. To date, there are no measurement tools examining the developmental process to independent cycling in the early childhood years. The current study aimed to develop and assess the inter-rater and test-retest reliability of the 'KIM Cycling Scale'.

Methods: Development of the scale occurred in four phases: (1) development of criteria and stages, which used observation of children when learning to cycle and expert panels to develop the initial developmental stages, (2) review of instructions and criteria and pilot inter-rater and test-retest reliability, to ensure that the scale could be used as a standalone scale without requiring further instructions (3) cycling intervention, which allowed assessment of the developmental nature of children along the scale as they learn to cycle independently and to assess typical and alternate routes to independent cycling and (4) inter-rater and test-retest reliability.

Results: Ninety children took part in phase 1, thirty-six children took part in phase 2, seventy-four children took part in phase 3 and one hundred and forty-nine children took part in phase 4. All three hundred and forty-nine children were between 2 and 6 years. The developed scale included eight stages in total. The scale was found to have excellent inter-rater reliability (ICC = 0.97, 95% CI = 0.96–0.98) and good to excellent test-retest reliability [(ICC = 0.91, 95% CI = 0.87–0.94) & (ICC = 0.90, 95% CI = 0.85–0.93)]. Typical routes to independent cycling along the scale were examined and reported as being step-wise on all occasions except one where a two stage jump was as common as the step-wise route. Alternate routes were also reported.

Conclusion: The current study developed a reliable measurement tool for assessing children between 2 and 6 years of age on the developmental process to independent cycling. Having a cycling scale will allow teachers and practitioners to assess competence in cycling and moreover, track changes in skill development. Furthermore, parents could also use the scale to better understand and better asses their child's progression when learning to cycle.

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Introduction

Independent cycling is the ability to cycle a traditional bike without the assistance of a person holding on to support the cyclist or additional 'training' wheels. Learning to cycle independently without assistance is a milestone for most children and is one of the most commonly reported active recreational pastimes during early childhood (Dunst, Hamby, and Snyder 2009; Nielsen, Pfister, and Andersen 2011) as well as being one of the most commonly reported physical activities globally (Hulteen et al. 2017). A systematic review on the health benefits of cycling in childhood and into adulthood have shown consistent, strong, positive relationships between cycling and cardiorespiratory fitness (Oja et al. 2011). Importantly, Oja and colleagues also found that those who cycled to school were five-times more likely to be in the top quartile of fitness compared to those who walked or passively commuted. A longitudinal study found fitness to have significantly increased by 6–21% in children who changed to cycling from non-cycling to school over 6 years (Cooper et al. 2008). Moreover, cycling is an important lifelong skill as it can be used recreationally, for sport or for transportation. The importance held for cycling globally is evident through the allocation of specific strategies and funds to increase cycling participation and improve infrastructure for everyone and specifically children (European Cyclists' Federation 2017; WHO 2004). Encouraging children to learn to cycle independently from a young age can be central to many people in increasing opportunities for a physically active life.

While assessment tools have been developed to evaluate the level of cycling skill in 5–13 year olds, with a focus on cycling safety (Arnberg et al. 1978; Ducheyne et al. 2013; Macarthur et al. 1998), these tools are for children who can, already, cycle independently. To the authors' knowledge, no studies have assessed the developmental process to cycling independently in children (2–5 year olds).

Typically research on physical activity and motor competence has focused on fundamental movement skills such as locomotor and object control as these were thought to be the building blocks of motor development (Clark 2005) from which more specialised skills arise (Stodden, Langendorfer, and Roberton 2009). Many interventions have been designed with the aim of improving fundamental movement skills in the preschool years (Altunsöz 2015; Bardid et al. 2013). While fundamental movement skill acquisition is undoubtedly important at this age (Logan et al. 2015; Lubans et al. 2010; Robinson et al. 2015), as demonstrated in numerous interventions (Altunsöz 2015; Bardid et al. 2013), it has been proposed that more lifelong physical activities such as cycling warrant focus, particularly during the critical development window of 2–6 years of age (Hulteen et al. 2018).

Cycling interventions that focus on cycling safety with children who already know how to cycle independently are common in primary school education (Ducheyne et al. 2014; Goodman, van Sluijs, and Ogilvie 2016; Hatfield et al. 2015; Montenegro 2015; Richmond et al. 2014). These interventions have shown an increase in cycling skills, confidence on the bike and knowledge of cycling safety (Ducheyne et al. 2014; Hatfield et al. 2015; Montenegro 2015; Richmond et al. 2014). In evaluations of two of the school-based cycling programmes, 'CYCLE Kids' and 'Safe Cycle', teachers reported that the programme increased the desire to cycling outside of school, increased excitement about exercising, overcoming fears of riding bicycles (Montenegro 2015) and increasing confidence and cycling participation (Hatfield et al. 2015) to be important outcomes of the interventions. Furthermore, students were reported as having higher collaborative and empathetic behaviours towards other students and improving on their relationships with teachers (Montenegro 2015). One challenge mentioned by teachers on the 'Safe Cycle' programme was that the programme assumed that all students could ride a bike, which was not the case and caused some issues. A recommended solution to this was delivery of a learning to ride programme in the earlier years.

Risk awareness and the value of risk are important factors to consider in preschool education. Cycling and particularly learning to cycle is a risk and so interventions based around learning to cycle could be considered as risky play interventions. An important factor in exposing children to risky play is that overcoming challenging situations like learning to cycle is an essential part of living a meaningful and satisfying life (Gill 2007). Cycling interventions in the preschool years may provide many benefits to children; however, tools need to be developed to aid teachers and practitioners in understanding the developmental process to learning to cycle independently in order to provide them with the information needed to carry out an intervention seeking to teach children to cycle independently. While risk taking is important, a fall from a bike when a child was not ready to cycle without assistance may discourage a child from trying again. A measurement tool to assess the development of independent cycling would be an extremely useful tool in this instance to allow teachers and practitioners to have better insight into when it would be appropriate to remove assistance.

Hulteen and colleagues developed a test battery to measure some of the other proposed lifelong physical activities (grapevine, golf swing, jog, push-up, squat, tennis forehand, upward dog and warrior) in 14–16 year olds in an effort to capture the proficiency levels of skills considered as popular physical activities in adulthood (Hulteen et al. 2018). In a list of important skills, cycling did rate high by experts when asked: 'how well does the skill fit the definition of lifelong physical activity?' and 'is there a need to increase skill competency of this skill', thus demonstrating the need for a measurement tool to assess the development of cycling ability. Unfortunately, cycling was not included within the test battery due to feasibility issues in assessing the skill in a school setting (Hulteen et al. 2018). Such a measurement tool would enhance understanding of competence in the development of the skill of cycling in the preschool years, thereby facilitating the promotion of cycling as a lifelong skill along with the fundamental movement skills. Specifically, it will allow teachers and practitioners to assess competence in cycling and moreover, track changes in skill development. This could also be used as a guide for parents when teaching their children to cycle. This would allow more effective intervention design to being employed and may also highlight any individual motor development issues a child may incur, giving an overall better understanding of their motor capabilities. The overall aims of the present study are to: (1) develop a scale that assesses cycling ability in 2–6 year old children, and (2) test the developmental nature, inter-rater and test-retest reliability of the scale in a sample of Irish preschool children.

Materials and methods

The development of the KIM (Kavanagh Issartel Moran) Cycling Scale occurred in four phases (Figure 1). The development was performed using an iterative approach where each phase informed further amendments to the scale. Phase 1 was the initial development of the scale through observation. Phase 2 was a two part pilot assessment of cycling ability using the scale. Firstly, discussions were had with two testers to ensure the scale was self-explanatory without needing further instructions. Instructions or explanations that were not understood were noted and changes subsequently made. Secondly, a pilot inter-rater and test-retest reliability was performed to see if any changes to the stages needed to be made. Phase 3 was performed to investigate if children progressed step-wise through the stages and thus confirming the scale as developmental. As the scale used in phase 2 relied on researchers verbally clarifying and explaining the scale to the testers, phase 4 involved a final inter-rater and test-retest reliability, using the amended scale, with two new testers who solely used the written instructions for implementing the scale. This was done so that reliability of the scale could be determined in the same setting as it would be administered by users (e.g. teachers, practitioners and parents).

Phase 1: development of the criteria and stages

The three authors of the study (a sports biomechanist, a motor learning expert and an experienced cycling instructor) designed the 'KIM Cycling Scale'. The actions of children and assistants were observed during the assessment of 90 preschool children (3.57 ± .54 years old; 38% female) on their ability to cycle independently. The observations were used to create stages of development.

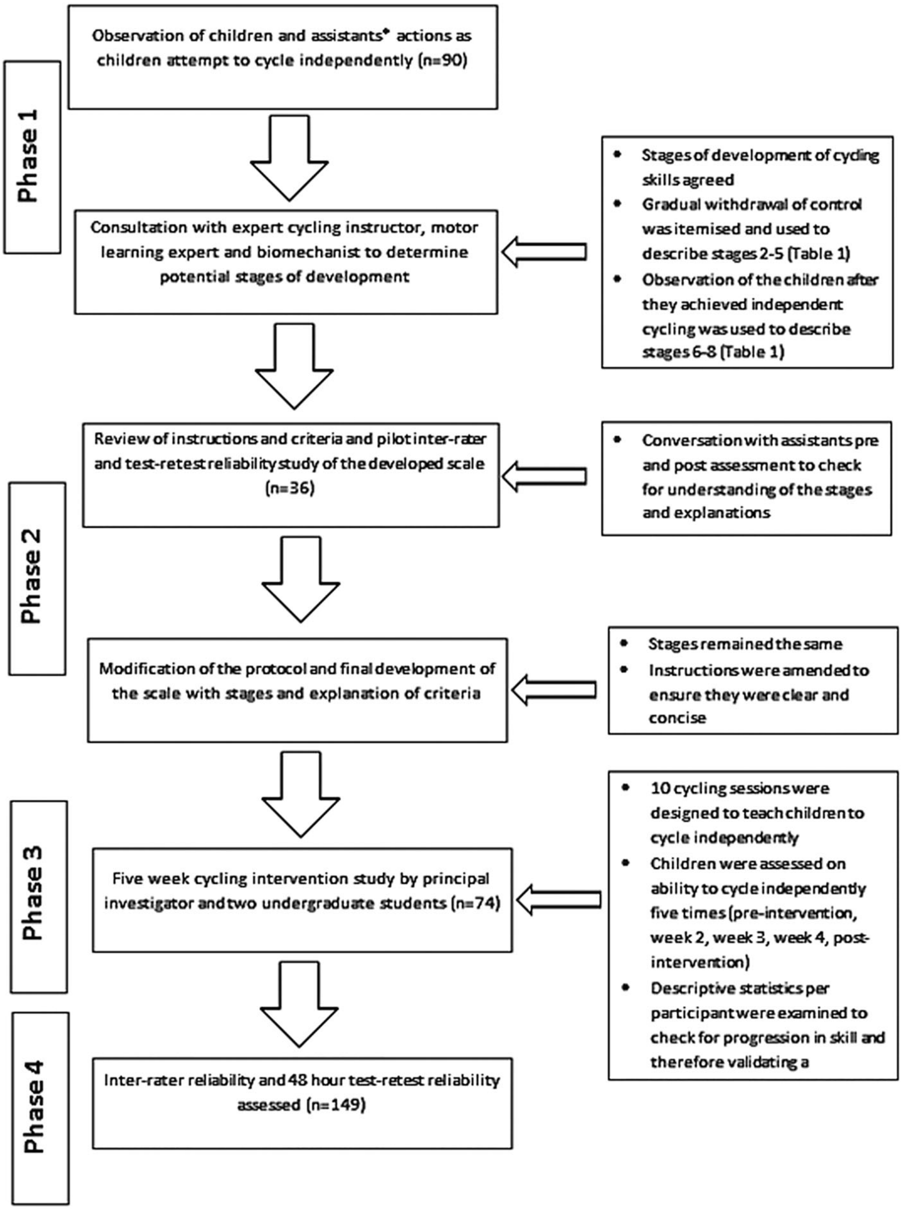

Figure 1. Development of the KIM Cycling Scale. *Assistant refers to those providing assistance to the child on the bike by holding on and gaining some control of the bicycle to help the child cycle.

Content validity was established by holding a number of meetings to discuss how the assistants recognised the necessary skill achieved by the child to allow a gradual withdrawal of control over time. The observed actions used by the assistants to gradually withdraw control were itemised and used to describe the criteria for stages 2–5, while observation of the children after independent cycling was achieved was used to describe stages 6–8 (see Table 1). Panel discussions were then used ensure that the stages captured changes in ability to cycle across the continuum of learning to cycle independently. When 100% agreement was reached by the three authors, development stages were itemised for each of the criteria and instructions for the tester were produced (Table 1).

Table 1. Instructions and criteria for testers and scoring system for the KIM Cycling Scale.

Instructions for tester:

- Begin by placing your preferred hand in the middle of the handlebars and allowing the child to get onto the bicycle.
- When the child is comfortable, place your second hand on the back of the seat
- Allow the child to set the speed at which they travel, do not use your own force to push the bicycle, apart from at the beginning when you may use force to initiate the movement.
- If the child is unable to pedal, give instructions on how to pedal.
- If the child is comfortable to go faster, allow them to do so, bringing your speed to a jogging pace.
- Instruct the child to 'keep their head up and look straight ahead'. Encourage them to 'keep pedalling', particularly if you are attempting to withdraw assistance
- Once past number 1 on the scale, rate the child's performance only when a jogging pace is reached.
- Minimum distance per trial is 15 metres.
- Award the child the highest stage reached for each trial.
- Take best score out of three trials.

Stage	Development stage	Criteria
0	Won't get on	The Child will not get on the bicycle
1	Full support needed	Requires firm hold of handlebars and seat, and child not able to pedal forwards
2	Full support needed	Requires firm hold of handlebars and seat, with child pedalling forwards
3	Semi-support needed	Requires intermittent hold of handlebars and firm hold of seat (Withdraw control of handlebars for at least 1 revolution of pedals)
4	Intermittent semi-support needed	Requires no hold of handlebars and intermittent hold of seat (Withdraw control of seat for at least 1 revolution of pedals while no hold of handlebars occurs)
5	No support but uneasy	Requires no holding of either handlebars or seat for more than 3 revolutions but cycling is not smooth (e.g. foot to ground contacts/wobbling)
6	Semi-Independent Cycling	Cycles smoothly with no holding once movement has begun but can't initiate cycling by themselves
7	Independent Cycling	Can initiate cycling by themselves and rides smoothly, but can't turn at least 180 degrees[a] smoothly while cycling (foot to ground contacts/wobbling)
8	Independent Cycling	Can initiate cycling by themselves and rides smoothly and turns at least 180 degrees[a] smoothly

[a]180 degrees can be completed by one 180 degree turn or two 90 degree turns.

Phase 2: review of instructions and criteria and pilot inter-rater and test-retest reliability

A pilot reliability study was completed (n = 36; 28% female) by the principal investigator and two assistants (CP and SB) to assess the inter-rater reliability and the test-retest reliability of the scale in preschool children (3.78 ± .64 years old). Discussions with the assistants were used to amend the instructions to ensure instructions were easy to understand prior to testing (final instructions in Table 1).

Phase 3: cycling intervention

A cycling intervention was designed to teach a convenience sample of preschool children (n = 74; 4.04 ± .48 years old; 53% female) to cycle to examine if progression occurred as proposed on the scale (Table 1). The cycling intervention consisted of two cycling sessions a week for five weeks on either balance bikes or bikes with stabilisers.

The principal investigator and an assistant (JMcW) together delivered all the classes. The intervention was delivered either during school time with a teacher present or outside of school time with one parent for each child present. Each class was designed to be fun and engaging for the children using games designed to teach speed, stopping, balance, control, coordination, agility and reactions (see Table 2). Each group consisted of 8–10 children and was 45 min in length. The children were instructed to arrive 10 min prior to each session so their bikes (balance bike or bike with stabilisers) could be adjusted to their size and helmets strapped on. Each 45-minute class was split into 35 min structured play and 10 min free play where the children either decided on the game they would like to play or designed their own game, instructing the practitioners on what they would need them to do. A teddy bear mascot named 'Ryder' was also involved during the sessions to provide comfort to the children. An example of the typical layout for the intervention is shown in Figure 2. An

Table 2. Description of games.

Game	Description
Traffic Lights	Using a bat with both red and green sides, instruct the children to ride around the hall, stopping when they come to a 'red light' and continuing when they see a 'green light'. The children can take turns being the traffic lights.
Chasing[a]	Allow the children to chase the practitioners. The practitioners can also go on the balance bikes for added fun if they are comfortable to do so.
Puddles	Place four poly dots on the ground in a straight line to act as puddles. Instruct the children to try go as fast as they can and when possible to lift both their feet when going over the puddles to avoid getting "wet".
Mr. Wolf[a]	The wolf stands on one side of the hall and the children on the other. The children can move when the wolf has their back to them but when the wolf turns around, they must freeze. When the children reach the wolf, they must turn and go quickly back to the start line as the wolf chases them. The children can take turns being the wolf.
Snake	Using cones, create a snake with lots of twists and turns for the children to follow.
Animal Reactions	Allow the children to ride anywhere they want in the hall. When the practitioner says freeze the children must stop and then make whatever animal noise the practitioner calls out. To make this more challenging, obstacles and puddles can be placed around the hall.
Safari[a]	Place a lot of cones on one half of the hall. Underneath some of the cones place different animals (cut outs on cardboard). Instruct the children to go and look under the cones for the animals. When they find one, they must bring it back to the practitioners on the other side of the hall and place it over the picture of the animal they found. They can then go back and look again.
Ryder's Birthday[a]	To celebrate our mascot's birthday, the children must first organise the party. Place numbers 1 -10 around the hall to represent door numbers and a teddy bear at each house then place signs to represent the post-office, the shop and Ryder's house. All the children are given felt baskets to hang off their handlebars. The children must first bring the invitations from Ryder's house to the post-office. From there, the invitations are put in order from 1–10 with the children's help. The invitations must then be delivered to each corresponding house. The teddy bears must then be collected and brought to the shop to pick a present for Ryder. The teddy bears and presents are then brought to Ryder's house for the party.
Musical Statues	Allow the children to ride around the hall to the music. When the music stops, they must also freeze and continue when the music plays again.
Minefields	Place small beanbags on the ground. Instruct the children to move around the hall and when they go through the minefields of beanbags to try avoiding them by swerving in and out.
Easter Hunt	Like Safari but have little bunnies and chicks under the cones. This can be adapted to suit any holiday.
Football	Using a small foam football, instruct the children to work as a team to kick the ball into the goal.
Obstacles	Set up the hall with a mixture of snakes, puddles, traffic lights and minefields to allow them to show off all their learnt skills.

[a]Children's favourite games.

Figure 2. Typical layout of the 5-week intervention. Blue boxes represent days when ability to cycle independently was assessed. Purple text represents examples of the games chosen to be played during the 10 min free play.

additional 5 min was allocated after the 45 min session so the children could be provided with stickers and 'high-fives' as compliments for a good class and incentives for continued participation (Corepal et al. 2018). The children were tested on their ability to cycle independently using The KIM Cycling Scale both pre- and post-intervention, as well as immediately after the second cycling session on week 2, 3 and 4. All testing took place on a traditional bike (without stabilisers) by the principal investigator and two assistants (JMcW and SR).

Phase 4: inter-rater and test-retest reliability

One hundred and forty-nine children (4.03 ± 1.02 years old) were recruited from a convenience sample of preschool and primary school children. All participants attended two sessions, 48 h apart. Two assistants (DC and AB) scored the children on their ability to cycle independently in order to assess the reliability of the KIM Cycling Scale. Testers were given the scale (Table 1) three days prior to testing and instructed to learn the scoring system. No verbal explanation or additional information was given. Each tester separately implemented and scored the ability to cycle independently on all the children at different time periods on the same day and again on all the children 48 h later using the same protocol. Two separate school yards of 20 × 10 m each were used to ensure each tester could not observe the other tester and to avoid a contamination effect. No comparison of results or talking between testers was permitted. Each child was tested three times successively. A tester was assessing one child at the time. Children were instructed to cycle as best they could and were told that if the tester thought they were able to cycle by themselves without their assistance that they would let go but would still remain beside them. The children were allowed to withdraw from the study at any point if they did not feel comfortable (no children withdrew from the study). Children were required to wear a helmet.

For all four phases the parents of the participants were given a plain language statement and signed informed consent prior to testing. Ethical approval was granted by the Dublin City University Ethics committee (REC/2016/031).

Statistical analysis

Analyses were performed using SPSS version 23 (SPSS Inc., Chicago, IL, USA). Means and standard deviations were calculated at each time point during the cycling intervention (Phase 3) as well as for each tester during the two reliability studies (Phases 2 and 4). Descriptive statistics to asses changes in mean scores over the five week cycling intervention were used to examine progression of ability at cycling in Phase 3. Interclass correlations (ICC) and their 95% CI were used to assess both inter-rater and test-retest reliability for both Phase 2 and Phase 4. For both inter-rater and test-retest reliability a two-way random effects, absolute agreement, single measurement and multiple raters model was performed [ICC (k,2)] (Koo and Li 2016). The classification proposed by Portney (Portney and Watkins 2000) was used to determine the strength of reliability using CIs of the ICCs as the reference, with poor reliability identified as a value <0.50, moderate reliability between [0.50–0.75], good reliability between [0.75–.90] and excellent reliability >0.90 (Koo and Li 2016; Portney and Watkins 2000).

Results

Phase 1

As indicated in the Methods section, the result of phase 1 was the initial development of the criteria and stages of the KIM Cycling Scale.

Table 3. Reliability of the KIM cycling scale in Phase 2.

Inter-rater reliability	Test-retest reliability		Session 1	Session 2
ICC (95% CIs)	Tester	ICC (95% CI)	Mean (SD)	Mean (SD)
.91 (.83-.96)	1	.95 (.91–.98)	2.91 (2.07)	2.70 (2.13)
	2	.94 (.87–.97)	2.97 (2.19)	2.82 (2.18)

Table 4. Scoring on the KIM Cycling Scale over five weeks [Mean (SD)].

Time-point				
T1	T2	T3	T4	T5
2.05 (0.92)	3.12 (1.39)	3.88 (1.62)	4.51 (1.75)	5.43 (1.99)

Phase 2

Instructions were adjusted and explanation of stages 4, 5 and 6 altered to provide better clarity to the testers. Good to excellent ICC and respective CIs were observed for inter-rater reliability and for test-retest reliability (Table 3). The average stage reached by the children was stage 3 over both sessions (Table 3).

Phase 3

Mean and standard deviations for scores on the KIM Cycling Scale across the five time-points [pre-intervention (T1), week 2 (T2), week 3 (T3), week 4 (T4) and post-intervention (T5)] during the cycling intervention are presented in Table 4.

Changes in the percentage of children who moved from one stage to another across the time points are presented in Table 5. The table demonstrates the progressive nature of the stages as

Table 5. Development of cycling ability (Stage S1-S8) across five time points (T1-T5).

	T1		T2			T3			T4			T5	
Stage 1	$n=24$	$n=7$	S1	29%	$n=5$	S1	71%	$n=2$	S1	40%	$n=2$	S1	100%
			S2	38%		S2			S2	60%		S2	
			S3	25%		S3	14%		S3			S3	
			S4	8%		S4	14%		S4			S4	
Stage 2	$n=29$	$n=13$	S2	14%	$n=3$	S2	23%	$n=4$	S2	33%	$n=1$	S2	25%
			S3	69%		S3	77%		S3	33%		S3	75%
			S4	17%		S4			S4	33%		S4	
Stage 3	$n=17$	$n=35$	S3	47%	$n=31$	S3	51%	$n=14$	S3	39%	$n=6$	S3	21%
			S4	24%		S4	40%		S4	48%		S4	43%
			S5	6%		S5	9%		S5	10%		S5	14%
			S6	6%		S6			S6			S6	21%
			S7	18%		S7			S7	3%		S7	
Stage4	$n=4$	$n=14$	S3	25%	$n=18$	S3	16%	$n=26$	S3	6%	$n=17$	S3	
			S4	50%		S4	25%		S4	56%		S4	42%
			S5			S5	42%		S5	22%		S5	12%
			S6	25%		S6	17%		S6	6%		S6	31%
			S7			S7			S7	11%		S7	12%
			S8			S8			S8			S8	4%
Stage 5	$n=0$	$n=0$	S5		$n=9$	S5	50%	$n=8$	S5	11%	$n=7$	S5	25%
			S6			S6			S6	67%		S6	50%
			S7			S7	50%		S7	22%		S7	13%
			S8			S8			S8			S8	13%
Stage 6	$n=0$	$n=2$	S6		$n=3$	S6	50%	$n=9$	S6	67%	$n=20$	S6	56%
			S7			S7	50%		S7	33%		S7	11%
			S8			S8			S8			S8	33%
Stage 7	$n=0$	$n=3$	S7		$n=3$	S7	33%	$n=6$	S7		$n=5$	S7	
			S8			S8	67%		S8	100%		S8	100%
Stage 8	$n=0$	$n=0$	S8		$n=2$	S8		$n=5$	S8	100%	$n=16$	S8	100%

Note: Any rows that have been removed across all timepoints indicate a non-occurrence. n; number of children at the respective stage and time point.

children develop the ability to cycle independently. Each time-point is represented by the letter ‘T’ and each stage of the scale represented by the letter ‘S’ (see Table 1 for description of stages). Seventy-four children were assessed at each of the five time-points and each child was given a score representing the Stage his/she was at. The values adjacent to the 8 different stages (S1-S8) represent the percentage of the children from that stage in the previous time-point that achieved that stage at the following time-point (Table 5). For example, at time-point 1 (T1) there were 24 children at stage 1; by time-point 2 (T2), 29% of those children remained at stage 1 ($n = 7$), 38% progressed to stage 2 ($n = 9$), 25% progressed to stage 3 ($n = 6$) and 8% progressed to stage 4 ($n = 2$). Similarly, at time-point 2 (T2) there were 35 children at stage 3; by time-point 3 (T3), 51% of those children remained at stage 3 ($n = 18$), 40% progressed to stage 4 ($n = 14$), and 9% progressed to stage 5 ($n = 3$).

Phase 4

Excellent ICC and respective CIs were observed for inter-rater reliability and good to excellent ICC values were observed for test-retest reliability, indicating overall high reliability for the KIM Cycling Scale (Table 6). The average stage reached by the children was between stage 3 and stage 4 over both sessions (Table 6).

Discussion

The current study developed a scale to assess a child’s level towards cycling independently. To the authors’ knowledge this developmental scale is the first study to develop such a scale. The KIM Cycling Scale was developed for preschool children between 2 and 6 years old. The KIM Cycling Scale was developed to include an 8-point scale ranging from full assistance is needed (stage 1), to no assistance needed and the cyclist can begin cycling themselves and turn smoothly (stage 8) (Table 1). After the initial stages were agreed and designed for the scale (phase 1), a reliability study was performed which found the KIM Cycling Scale to have high inter-rater and test-retest reliability (Phase 2), indicating the KIM Cycling Scale to be reliable across testers and over time. This scale was developed to be a standalone scale with written instructions for the tester so that no further reading or verbal/visual instructions would be required to perform an assessment. Similar to the pilot reliability study (Phase 2), the KIM Cycling Scale was found to have high inter-rater and test-retest reliability in Phase 4 when there were no verbal explanations prior to testing. The high level of reliability is similar to the high levels found in other test batteries assessing alternative lifelong physical activities such as grapevine, golf swing, jog, push-up, squat, tennis forehand, upward dog and warrior (Hulteen et al. 2018).

To ensure that the scale was developmental in nature, a five-week cycling intervention was run. This was performed to investigate if children progressed step-wise through the stages. Table 5 presents data on how children progressed through the stages throughout the five-week intervention (Phase 3). The most frequent forms of progression were step-wise from one stage to the immediate next stage (for example stage 1 to stage 2), apart from stage 4 which had two typical routes, one step-wise to stage 5 and another transitioning from stage 4 straight to stage 6. The observed progression conforms to the universal definition of development in that each stage was achieved before the next. While generally step-wise progression was the typical route observed for the children in this study, it does not apply to everyone and individual differences occurred resulting in alternative possible

Table 6. Reliability of the KIM Cycling Scale in Phase 4.

Inter-rater reliability ICC (95% CIs)	Test-retest reliability		Session 1	Session 2
	Tester	ICC (95% CI)	Mean (SD)	Mean (SD)
.97 (.96-.98)	**1**	.91 (.87–.94)	3.55 (2.32)	3.78 (2.49)
	2	.90 (.85–.93)	3.44 (2.37)	3.71 (2.50)

routes to independent cycling. Figure 3 demonstrates the typical and alternative routes to independent cycling as observed in the current population. The variety of learning trajectories reflect both the complexity of the skill to be learnt and inter-individual differences (Magill 2004).

Having typical and alternative routes was first theorised by Gesell (Gesell 1939) and then observed by Adolph (Adolph and Robinson 2013) in the examination of developmental progression to independent walking. Research into the development of locomotive skills like walking and climbing stairs has highlighted that while the average child follows a step by step progression pathway (the 'typical route'), some children forge their own alternative paths, highlighting that the sequence of development can also be variable, similar to what is observed in the current study (Adolph, Berger, and Leo

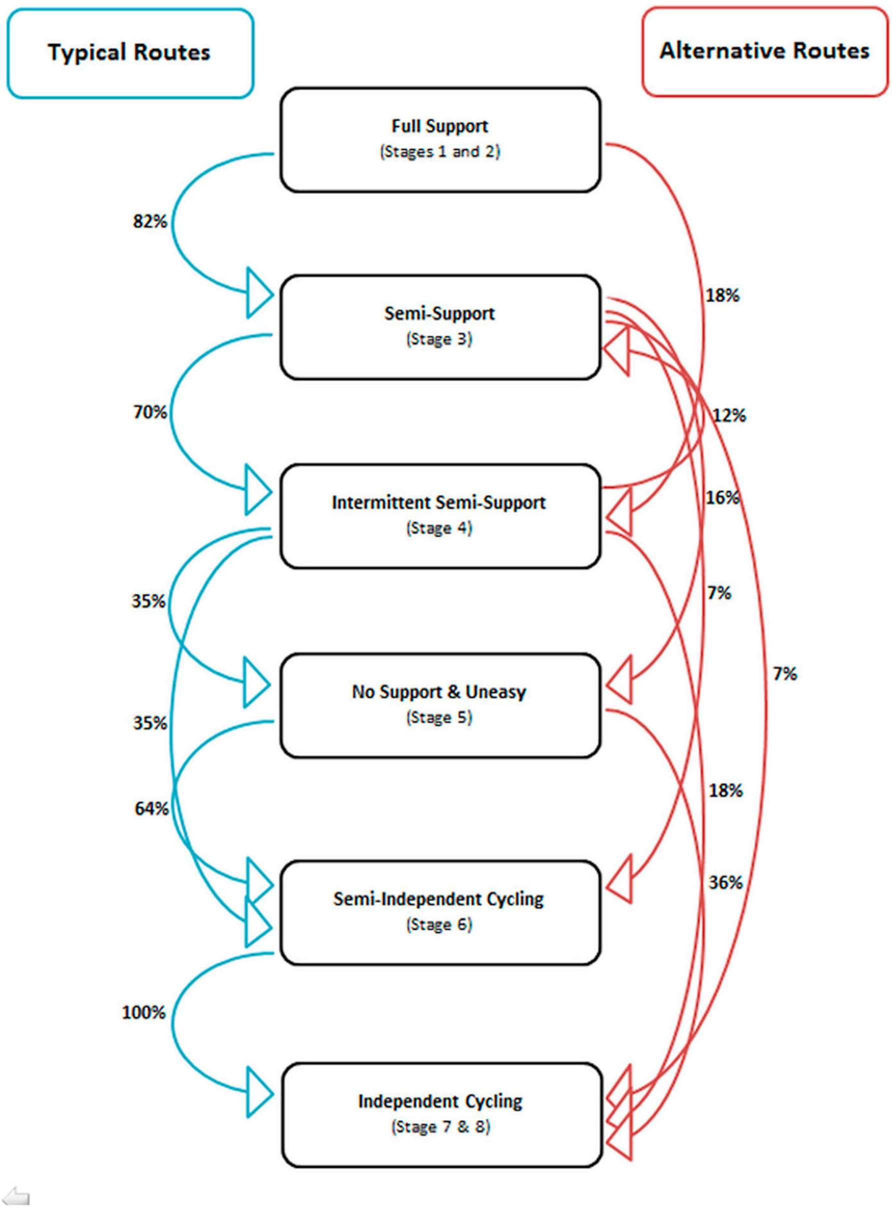

Figure 3. Typical and alternative routes to independent cycling.

2011; Berger, Theuring, and Adolph 2007). In the current study, 54% of the participants followed a typical route throughout T1-T5, with 32% using an alternative route once, 11% using an alternative route twice and 3% never progressing from T1-T5. Notably, it is not until Stage 3 is reached that we see the ability to progress straight to the first stage that represents independent cycling (stage 5). Regression in development occurred only between stage 4 and stage 3. It is not uncommon to observe regression between two stages as an alternative route in development of a skill (Vereijken and Adolph 1999). Fitts and Posner's three stage model demonstrates how there is a lack of consistency in performance from one attempt to the next due to high variability (Fitts and Posner 1967). This may explain the regression observed in the current study, when a seemingly learnt pattern could not be reproduced at the following assessment. Overall, the KIM Cycling Scale was supported as a development scale.

Evaluations by teachers and students of school-based cycling interventions have been very positive and well received by both teachers and students with the most common responses from students being that they are engaging and fun (Hatfield et al. 2015; Montenegro 2015). The KIM Cycling Scale will allow teachers, practitioners and parents to assess a child's ability to cycle independently and encourage learn-to-cycle interventions in preschools, which will allow children the opportunity to learn to cycle independently before entering primary level education. Having a scale from which levels of cycling ability can be measured can inform the construction and implementation of learn-to-cycle interventions within community and school curriculums by allowing investigation into the effectiveness of these interventions and by exploring other factors that may contribute to learning to cycle independently. Furthermore, the KIM Cycling Scale will allow teachers and practitioners to have a better understanding of when a child may be ready to cycle independently and therefore when may be appropriate to remove assistance. There are also benefits of testing on a continuous scale; the feeling of progress in a skill may encourage self-belief. Such enactive-mastery (Bandura 2002) is thought to encourage further practice and trials from a child, whereas without a scale a child (and their teachers) could only distinguished as either being able to cycle independently or not. Having a scale that exhibits progress also provides feedback to the dyad teacher-learner for all stage of learning. Results from the current cycling intervention on the KIM Cycling Scale very rarely showed a child not progressing in cycling ability. This can offer assurances to teachers and practitioners when conducting a cycling intervention that practicing will lead to steady step by step improvements. Additionally, the health benefits and positive wellbeing that comes from engaging in cycling activities (Oja et al. 2011).

Recommendations from the current cycling intervention include the use of fun games and constant encouragement to the children, appropriate training and resources for the teachers and practitioners along with specific training in relation to managing groups of children on bikes (Hatfield et al. 2015). Furthermore, some children are less likely to want to try cycling independently than others at first. Allowing the more willing children to go first, often exhibits to the others that it is ok and trust is gained in knowing the teacher will not withdraw assistance unless the child is ready and comfortable. The current cycling intervention found that after some encouragement from teachers, practitioners and other children, all children were willing to participate in the assessment of cycling ability at each of the timepoints turning the testing time into a fun and engaging activity. It has been previously recommended to involve parents in motor skill interventions as they are a key factor in habitual and lifelong development (Riethmuller, Jones, and Okely 2009). This is further highlighted in recommendations for preschool children, that emphasise the pivotal role parents have for providing encouragement, opportunities and support for physical activity (American Academy of Pediatrics. Council on Sports Medicine and Fitness 1992; Hagan, Shaw, and Duncan 2017; Wright and Stork 2013). Teachers and practitioners should be advised to allow parents access to the scale used to assess their child's cycling ability, thus promoting indirect involvement from parents during the intervention. Furthermore, encouraging parents to become familiar with the KIM Cycling Scale and the typical and alternate routes to independent cycling (Figure 3) provides parents with the information required to aid in their child's cycling journey as well as gaining an understanding that children develop their cycling ability in different way. Cycling has been recently added to the motor development model as an important lifelong skill in early childhood (Hulteen et al. 2018) and so it is important that there is a valid and reliable measure of cycling ability during the development process of learning. Alternative assessment tools have recently been developed to assess other lifelong physical activities in an attempt to promote these skills along with the traditional fundamental movement skills (Hulteen et al. 2018). Having a wider array of skills allows for a greater chance of a physically active life (Goodway and Robinson 2015) which has been extensively linked to a healthier life (Warburton and Bredin 2017). Moreover, cycling itself has been linked with significant health benefits from early childhood into adulthood (Kelly et al. 2014; Oja et al. 2011) and with strategies in place to ensure the development and upkeep of infrastructure to promote cycling as a means of active commuting (European Cyclists' Federation 2017; WHO 2004), it is imperative that we encourage development of the skill in the early childhood years. Therefore, the development of test batteries to assess lifelong skills, and in particular cycling in the early childhood years, may have significant benefits to aid the promotion of a physically active life.

The current study has addressed this with the development of the KIM Cycling Scale which should help with the design of more effective interventions to improve cycling ability, as well as facilitating future research to investigate factors that may contribute to independent cycling. The scale will also allow teachers and practitioners to track changes in the development of independent cycling. Furthermore, parents may use the KIM Cycling Scale as a tool to better understand and better assess their child's progression when learning to cycle. The lack of a valid and reliable cycling scale may, at least in part, explain the lack of research to date into the process of learning to cycle. In summary, this study developed a reliable measurement tool for assessing children between 2 and 6 years of age on the developmental process to independent cycling.

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