Influence of elementary students walking speed to children pedestrian pathway planning

F P Makalew\textsuperscript{1}, S A Adisasmita\textsuperscript{1}, S Wunas\textsuperscript{1} and S H Aly\textsuperscript{1}

\textsuperscript{1}Faculty of Engineering, Departement of Civil Engineering, University of Hasanuddin, Makassar, Indonesia

E-mail: febriani.makalew@yahoo.com

Abstract. Children pedestrian use pathways for access on their journey. As part of the infrastructure, the pedestrian pathway for elementary students, require adequate access to and from school. Among studies on pedestrian, research on child pedestrian walking speed is limited. Child pedestrian speed is influenced by walking time and distance. This research aim is to analyze children's pedestrian walking speed and its influence on children's pedestrian pathways. The method of research is a field survey with recorded elementary student’s pedestrian area of walking and their behavior. Data is collected from the video and photo recorded of 14 elementary schools in the urban area and 9 elementary schools in the rural area in North Sulawesi, Indonesia. This study involves elementary students age from 6 to 12 years old from grades 6 to 12. The analysis is a comparison of student pedestrian speed in the urban and rural areas and with previous research. Due to most pedestrian children behavior is to run to and from school, the children's pedestrian speed is higher than previous research. Considering the area along their walking time, facilities provided should be friendly and safe for children. Therefore, children, pedestrian pathway needs specific regulation considering the urban and rural area.

1. Introduction

Children's pedestrian walking speed is important in planning a pedestrian pathway. Children's behavior is as unique as a pedestrian. The way they use space to show how element available on the pathway influence their walking behavior [1, 2]. However, the facility on the pedestrian pathway in many streets in North Sulawesi is varied in the urban and rural areas. Some streets do not have an adequate facility on pathways for the pedestrian [3]. Moreover, walking distance for elementary students is increasing. By comparison with standard walking 400 meters and for elementary school distance 800 meters [4] also walking distance 1000 meters [5], the distance is longest. A preference for walking to school and school location in housing and settlement area are factors that influence walking distance. This research shows elementary students walking speed and walking distance. The comparison with previous research and standard available is important to see the differences and similarities in the urban and rural street.

Children's pedestrian walking speed and distance is part of research on the pedestrian. The previous study found that average speed for children is lower than older pedestrians [6]. In related to pedestrian speed, factors influence is personal characteristics, walking characteristics such as carrying goods and distance, infrastructure available and the character of the environment [7]. In related to behavior, the influence of walking speed is a micro character [7]. Also, distance influence pedestrian behavior [8].
Travel time and distance to school are factors that affect the decision to walk to school [9, 10]. The freedom for walking speed and free time to pass another pedestrian without disturbing each other is important in the planning dimension of the pathway [11]. The distance standard based study neighborhoods’ unit for the location of an elementary school is 800 meters [4].

2. Research method

The research location is pedestrian pathways of 23 schools in the urban and rural areas. The number of samples is calculated based on formula for a limited population of students in North Sulawesi, with a minimum of 383 students for each area [12]. The number of students is taken from BPS [13]. From the sample, available data for children pedestrian speed is for the rural area is 380 students and for the urban area is 483 students. Data is gathered by recording using the camera and smartphone. For distance, the area of the pathway is to measure the on-field area and compare it with distance on the map to get accurate data. Area of study is chosen based on preliminary research on the potential pedestrian area and in the fair distribution of location in the urban area and rural area. The number of students in urban and rural areas can be seen in figure 1.

![Figure 1. Number of students in urban and rural schools](image)
3. Result and Discussion
Data for children pedestrian walking speed is taken from the sample available from 23 elementary schools. The comparison of child pedestrian speed in the urban and rural areas and by previous research can be seen in Table 1.

| Type of Evaluation | Urban (m/sec) | Rural (m/sec) | Previous research/Standard (m/sec) | Source |
|--------------------|--------------|---------------|-----------------------------------|--------|
| mean               | 1.23         | 1.27          | 1.03                              | [6]    |
|                    |              |               | 0.8                               | [14]   |
|                    |              |               | 1.2                               | [14]   |
|                    |              |               | 1.5                               | [14]   |
| median             | 1.15         | 1.06          |                                   |        |
| modus              | 1.3          | 0.73          |                                   |        |
| max                | 4.46         | 5             |                                   |        |
| min                | 0.48         | 0.40          |                                   |        |

The average walking speed based on the HCM standard is 0.8 m/sec [14]. This walking speed considers a number of the elderly population where, for an area less than 20% elderly, the average speed is 1.2 m/sec. Free speed is 1.5 m/sec. In related to child pedestrian, the number considers a high number of slow walking children. The result of children's pedestrian speed is higher than previous research. Average children's pedestrian speed on the pathway in Rajshahi, Bangladesh, is 1.03 m/sec slower than the result 1.23 m/sec in an urban area and 1.27 m/sec in a rural area [6]. This result is higher than research before such as for youth 1.125 m/sec, middle-age 1.12 m/sec, and elderly 1.054 m/sec [6]. Also, other study for sixth grade walking speed is 10.6 seconds in the distance 50 ft or 1.48 m/sec [15].

The higher result of walking speed is caused by the dominant behavior of an elementary student to run to and from school [2]. The maximum result of walking speed 5m/sec is a result of a student running to school. A student running to school can be seen before and after school time. Based on a formula by HCM, pedestrian flow is counted. Pedestrian flow and capacity can be seen in Table 2 [14].

| Urban | Rural | Standard |
|-------|-------|----------|
| Sped  | 1.23 m/sec | 1.27m/sec | 1.2m/sec |
|       | = 73.8m/min | = 76.2m/min | [14]     |
| M     | 0.67m2/p   | 0.86 m2/p | -        |
| Vped  | 1.23/0.67  | 1.27/0.86 |          |
|       | = 73.8m/min/0.67 | = 76.2m/min/0.86 | -     |
|       | = 110.2p/min/m | = 88.6p/min/m | -      |
| Dped =| 110.2p/min/m | 88.6p/min/m | 75p/min/m |
| Vped/Sped | /73.8 | /76.2 | [14] |
|        | = 1.49p/m2  | = 1.16p/m2 |          |

The result shows that children's pedestrian capacity is higher than standard by HCM [14]. For a maximum walking distance of 1.2 km, the walking time in the urban area is 1200/1.23 equal 975.6 seconds or 16.26 minutes. While in the rural area is 1200/1.27 equal 945 seconds or 15.75 minutes. By
comparison, the walking speed standard for an adult is 1200/1.2 equal to 1000 seconds or 16.67 minutes. Maximum children's pedestrian walking distance in the urban and rural areas can be seen in table 3.

### Table 3. Elementary students maximum walking distance in the urban and rural area

| ELEMENTARY SCHOOL (ES) | DISTANCE (km) | URBAN/RURAL | SOURCE |
|------------------------|---------------|-------------|--------|
| ES GMIM Upper Winangun Minahasa | 1.1 | Rural | Puri Alfa Mas area | Questionnaire |
| ES INPRES Tambala Minahasa | 1.2 | Rural | Tambala Village | Questionnaire |
| State ES 15, 18 & 20 Manado | 0.65 | Rural | Tambala beach area | Interview |
| State ES Winangun Manado | 0.9 | Urban | Mahake ret 3, Samratulangi Street 12 & 13 | Questionnaire |
| State ES Winangun Manado | 0.6 | Urban | Lembah sari area | Questionnaire |
| State ES Winangun Manado | 0.7 | Urban | First Wina ngun area | |
| ES GMIM Paslaten North Minahasa | 1 | Rural | Paslaten Village | Survey |

Average distance walking and average walking time for all purposes is 0.7 miles or 1.13 km and 14.9 minutes, respectively [16]. Based on standard average walking time is 1.2 m/sec and for a distance, 1200 m result shows that average children walking time in the urban area are nearly similar to standard available while in a rural area is faster. Time spend along walking to school, and back home on the pathway area are varied for elementary students. They tend to use pathway space as wide as possible. Moreover, their behavior is dynamic and active such as running, playing, walking backward and walking in duck line [1]. Considering this condition, the area of the pathway should be planned based on children's pedestrian activity as well as to protect their walking area from being safe [17].

By comparison, previous research on walking speed and distance show differences. For neighborhood unit standard for 400m, need 5 minutes walking time. So, for 1000m need 12.5 minutes of walking time. Time spend by elementary students to walk from a distance up to 1200m if compare with this research show longer 3.76 minutes in an urban area and 3.26 minutes in the rural area. Result also shows that elementary students tend to walk more than average standard people to walk or maximum distance for the elementary student which is 800 metres or half a mile.

### 4. Conclusion

The children pedestrian walking speed and distance is different than an adult. Research shows the walking speed is higher than previous research. Moreover, walking distance is higher than the standard for adult and elementary student walking distance, which is up to 1.2 km. Although the distance is valued based on the longest distance in selected schools in the urban and rural area, the trend show similarity in terms of distance and walking behavior. The area on the pedestrian pathway, therefore, should accommodate elementary students’ activity in a safe environment. There is a need to include
children's pedestrian speed and distance in planning friendly pathways in the school area and it is surrounding.

References

[1] Makalew F P, Adisasmita S A., Wunas S, and Hamid S 2017. Children Pedestrian Movement Pattern on Pedestrian Pathway - Pola Pergerakan Pejalan Kaki Anak pada Jalur Pedestrian, National Seminar in Civil Engineering (SeNaTS) 2 Proceeding Book, Udayana University, Denpasar Bali

[2] Makalew F P, Adisasmita S A., Wunas S, and Hamid S 2017. Influence of Children Pedestrian Behaviour on Pedestrian Space Usage, IOP Conf. Ser.: Mater. Sci. Eng. 271 012 -028

[3] Makalew F P 2014. Identification of Urban Street Facility: Challenge for Walking as Environmental Friendly Transportation - Identifikasi Fasilitas Jalan Perkotaan: Tantangan Jalan Kaki Sebagai Transportasi Ramah Lingkungan, Studi Kasus Kota Manado, Proceeding Research Unit Manado State Polytechnic

[4] Clarence P 1929. The Neighbourhood Unit: From the 'Regional Survey of New York and Its Environs', Volume VII, Neighbourhood and Community Planning, Routledge

[5] Indonesia National Standard Board (NSB) Badan Standarisasi Nasional Indonesia 2004 SNI 03-1733-2004 Guideline for Housing Planning in Urban Areas, Tata Cara Perencanaan Lingkungan Perumahan Di Perkotaan

[6] Nazir M I, Al Razi K M A, Hossain Q S, and Adhikary S K 2014. Pedestrian Flow Characteristics at Walkways in Rajshahi Metropolitan City of Bangladesh, Proceedings of the 2nd International Conference on Civil Engineering for Sustainable Development, (ICCESD), KUET, Khulna, Bangladesh

[7] Daamen W, and Hoogendoorn S P 2003. Experimental Research of Pedestrian Walking Behaviour, Transportation Research Record 18 (28) 20-30

[8] Azmi, Diyanah I, and Karim H A 2012. A Comparative Study of Walking Behaviour to Community Facilities in Low-Cost and Medium Cost Housing, Asia Pacific International Conference on Environment-Behaviour Studies, Procedia - Social and Behavioral Sciences 35 619 – 628.

[9] McDonald N C 2008. Children’s mode choice for the school trip: the role of distance and school location in walking to school, Transportation 35 23-35.

[10] Oliver M, McPhee J, Carroll P, Ikeda E, Mavoa S, Mackay, L, Kearns R A, and Witten K 2016. Neighborhoods for Active Kids: study protocol for a cross-sectional examination of neighborhood features and children’s physical activity, active travel, independent mobility and body size. BMJ Open, 6: e013377

[11] National Standard Board (NSB) Badan Standarisasi Nasional. 1991. SNI 03-2443-1991 Pathway - Trotoar

[12] Krejcie, Robert V, and Morgan D W 1970. Determining Sample Size for Research Activities, Educational and Psychological Measurement 30 607-610.

[13] Biro Pusat Statistik (BPS) Statistic of North Sulawesi Province 2016 Social North Sulawesi in figures (BPS-Statistics of North Sulawesi Province) chapter 4 pp 81 – 142

[14] Transportation Research Board (TRB) 2000. Highway Capacity Manual (HCM), National Research Council Washington DC

[15] David K S and Sullivan M 2005. Expectations for Walking Speeds: Standards for Students in Elementary Schools. Pediatr Phys Ther. Summer 17 (2) 120-127.

[16] Yang, Yong and Diez-Roux, Ana V. 2012. Walking Distance by Trip Purpose and Population Subgroups, Am J Prev Med. Jul 43 (1): 11–19

[17] Makalew F P, Adisasmita S A, Wunas 2018. Pedestrian Space Capacity and Movement Pattern For Elementary Students In Urban And Rural Area, International Journal of GEOMATE 15 (50) 63 – 69.