

Digital Human Modeling to Predict Passenger Comfort: A Case of Indonesian *Angkot*

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Abstract— This paper presents an evaluation of *angkot*, which was conducted to address ergonomic issues related to this mode of transport and to support the development of design recommendations for *angkot* use by the Indonesian population. This was achieved by carefully investigating the way people sit inside the *angkot*, modeling and running simulation to assess comfort, and finally proposing a design recommendation that is likely to be more ergonomic and healthy based on the simulation. A contextual inquiry method using video observation was applied to investigate sitting postures that appear most often among passengers. The analysis revealed that the most common sitting postures were sitting fairly upright, with the head facing down to the floor or facing front to the direction of travel; meanwhile, both arms were supported, and both legs were free on the floor. JACK Digital Human Modelling (DHM) software was used to perform Rapid Upper-Limb Assessment (RULA) analysis, which revealed a number of commonly adopted postures that require correction. A new seating layout is proposed based on the analysis and best practices from literature. RULA analysis was reapplied to the design changes to check the anticipated postures that would emerge i.e. passengers are facing towards the front of the bus, which is more likely to be ergonomically better for their comfort and health. This paper also discussed its limitations and potential future works. Future study of similar phenomena is still wide-open to obtain a more thorough comprehension of *angkot* microbus.

Keywords— *Angkot*; sitting; Digital Human Modelling; Rapid Upper-Limb Assessment; contextual inquiry.

I. INTRODUCTION

In several cities in Indonesia, minibuses are still serving as an urban transport system. Minibuses, or *angkot* as its equivalent term, are basically a minivan, owned by the private sector, and having the passenger cabin modified to increase its capacity to practically maximum possible of around 12-14 passengers (from 6 passengers) with mostly side-facing seats [1]. Modifying *angkot* minibuses in this way raises concerns about the postures adopted by their passengers.

According to several observational studies on passenger behavior, sitting is the main activity of taking any public transports including buses [2]–[8]. Such activity can last for a long time during travel and may cause musculoskeletal discomfort [9]. Furthermore, sitting in a relatively long period of time may also have an impact on mental wellbeing and work productivity [10].

To date, there has been insufficient research regarding the passenger sitting postures on minibuses, even though minibuses are still serving worldwide, mainly in developing

world cities. A recent study [11] attempted to observe passenger behavior on traditional buses in Mexico, though did not specifically investigate sitting postures. However, the buses used in the study did not seem to be minibuses as the passengers were able to stand up. Most research on passenger sitting postures has been conducted on trains [12]–[15], with results showing that passengers tend to sit in different postures depending on the activities they are performing [14], [15]. In Indonesia, studies on *angkot* minibuses have been reported with different range of topics, e.g. public policy and economics [16]–[18], were [1], [19], [20], or safety [21]. Still, the literature seems to lack studies on physical ergonomics area, particularly related to passenger sitting postures.

There have been, however, research regarding sitting postures of passengers in similar microbus outside Indonesia. A study in Nigeria [22] attempted to run an evaluation regarding the compatibility of seating arrangements of the traditional *molue* buses. The *molue* buses have several similarities to *angkot* minibuses, particularly concerning their seats. Both *molue* and *angkot* use relatively small,

bench-style seats (seat depth: 320mm for *angkot*, 286mm for *molue*) with low backrests that only support passengers' lower back. However, they differ in seating arrangements. Since the *molue* tends to use bigger vans as their basis, they apply front-facing seating arrangements, whereas the *angkot* applies side-facing seating arrangements due to their restricted space. The study recommended both massive corrections to several essential seat dimensions, i.e. depth, length, height, and legroom, to reach maximum comfort for Nigerian population. Reference no. [23] conducted a similar study in Ethiopia. Both subjective and objective evaluation was taken using self-report and anthropometric methods. Based on the analyses, the authors found that passengers suffer inconvenience during travel because of discrepancies between passenger anthropometry and seating dimensions. These studies show a prominent issue from which every microbus in the world seems to be suffering, specifically associated with sitting activity. However, studies from Nigeria and Ethiopia merely compared the standard posture to the existing design.

Meanwhile, passengers might vary in terms of their sitting postures due to their activities during travel [14]. Therefore, comprehending this issue is essential to provide an initial stepping-stone for designing an ergonomically acceptable design of microbus in general and *angkot* in specific. Furthermore, the study can potentially uncover any covert issue regarding current design of such mode of transport. This paper thus aims to address ergonomic issues related to *angkot* microbus. This was attained by carefully investigating the way people sit inside the *angkot*, modeling sitting posture samples and running them in a simulation to assess comfort, and finally proposing a design recommendation that is likely to be more ergonomic and healthy based on the simulation.

II. MATERIAL AND METHOD

A. General Approach

This study involved three main phases, started with gathering the relevant data by means of contextual inquiry techniques [24], including in situ observation (using video recording), and taking measurements of seating and cabin dimensions as reference for design variables. JACK Digital Human Modelling (DHM) software (Siemens PLM) was assigned using the collected data to check Rapid Upper-Limb Assessment (RULA) scores of the postures. The result was used as the reference to propose design changes for the *angkot*. Finally, JACK was reassigned to check RULA scores of the anticipated postures that would emerge from the proposed design (based on academic literature) to determine the appropriateness of the new design.

B. Data Collection

1) *Video Observation*: Prior to the observation, an observation framework was created to set up a robust and structured in situ observation. The observation was conducted to capture possible sitting postures of *angkot* passengers. Both inductive and deductive approaches [25] were applied to analyze the video footage obtained from the observation. The inductive approach was applied first to probe various sitting positions of passengers. After these

positions were identified and classified using a postural classification technique by Branton and Grayson [14] (with some adjustments; see Table 1), sitting postures that appear most often can be obtained after counting frequency of posture appearance throughout five-minute time sampling strategy.

TABLE I
POSTURAL CLASSIFICATION FOR *ANGKOT* PASSENGER SITTING POSTURES
(ADAPTED FROM BRANTON AND GRAYSON)

Body parts	Denotation
Head (including neck)	Facing front; facing sideways; facing down; other positions
Trunk/back	Upright; bent over; leaned back; other positions
Arms	Supported; unsupported; holding something; other positions
Legs	Apart from each other; close each other; crossed; stretched forward; other positions

Video observation was performed in Bekasi, West Java, a commuter city situated 25 kilometers eastbound from Indonesia's capital city, Jakarta, and lasted for four days, including one day devoted to piloting the study. A one-day pilot study was purposed to obtain possible sitting postures, familiarize the route, and test the equipment. The rest three days were dedicated to collect the data. Each observation session took two return trips that lasted for approximately two hours during three different daytimes that randomly selected for each day: early morning and late afternoon (rush hours/peak) and midday (off-peak). This aimed to unfold various conditions that might affect passenger-sitting postures, e.g. crowdedness. The bus runs normally during an observation session, i.e. complete its designated route, take passengers, and charge them for the service.

One unit *angkot* microbus (a 2003 modified Suzuki Carry 1000) was employed for this study. The bus was serving on Line 09, an 18-kilometer route from Bekasi Railway Station in the center of the city to the district of Babelan in the north. GoPro cameras were mounted inside cabin in three different locations, allowing the whole cabin to be captured. Two copies of information sheet, printed on A3 paper and written in Bahasa Indonesia, were shown both inside and outside the cabin (near entry/exit door), giving essential information about the study so that passengers could opt to participate or not.

This study obtained ethics approval from the Faculty of Engineering, University of Nottingham.

2) *Cabin and Seating Dimensions Measurement*: The cabin and seating dimension measurements were taken by hand using a tape measure, targeting two parts: (1) seating area and (2) cabin structure dimensions. This strategy aimed to acquire actual size of existing cabin that would serve as the main reference in proposing new cabin design. Figure 1 shows measurement framework for this purpose.

C. DHM Modeling and Analysis

After sitting postures that appear most often can be successfully revealed, the next step is to model them into digital human modeling software. We used JACK (Siemens PLM) to perform this task, as this software is easy to use and popular among companies and universities for various

purposes [26], [27]. JACK is capable of providing flexible anthropometric scaling and high fidelity human model [28] so that it can perform several ergonomic analyses such as RULA (Rapid Upper Limb Assessment), NIOSH lifting equation, and working posture analysis [29]. There were several considerations when modeling the postures adopted by *angkot* passengers. Firstly, mannequin in DHM software should be modeled using anthropometric data that represent passenger population. Therefore, anthropometric data from [30] was used as it supplies a thorough and latest database for Indonesian population. Secondly, 50th percentile value was used for key anthropometric measures, e.g. stature as according to [31]-[33] it is sufficiently representative in evaluating a population. Finally, it was considered important to model mannequin for both sexes, male and female, significant differences in anthropometric dimensions do exist between male and female.

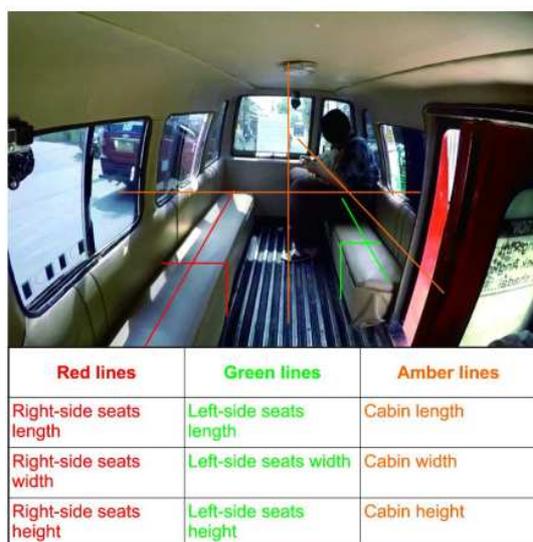


Fig. 1 Measurement framework for cabin and seating dimensions

The digital mannequin was modeled carefully to obtain valid model for each sitting posture. For this purpose, we undertook three steps. The first step was to produce *angkot* seat model inside JACK environment not only for visualization purposes but also for reference points that will be useful in the later steps. The next step, which was considered the main step, was to model sitting postures that appears most often from observation and data sampling. The process was completed manually using JACK's male predefined sitting postures as the starting point and then adjusted at several joints until it mimics the poses of observed postures. The final step was to copy the male mannequin to female mannequin, with several necessary adjustments associated with the joints that were applied to both models. Using JACK's Human Control dialog box, each body segment was manually adjusted to set up the joints. The steps were repeated in order to model each type of sitting posture. To avoid bias, both authors cross-checked the models and undertook necessary alterations. Once digital mannequin for all postures was ready, RULA (Rapid Upper Limb Assessment) toolkit was run to evaluate these sitting postures. Body group loading assumption as shown in Table

2 was considered and applied to male and female digital mannequin.

D. Design Recommendations

Designing principles have to be determined in advance before proposing changes in *angkot* cabin design, i.e. new seating arrangements. In every design, accommodating as many people within a population as possible is perhaps the main creed. However, this is not easy to achieve, as variability in anthropometric measures is most likely to exist within a population [13]. Therefore, a design strategy should be chosen carefully. A "design for extreme" principle was chosen for this design proposal as it is seen as an appropriate attempt to cover broad range of people in a population [34] since it involves both maximum and minimum value of anthropometric data (95th and 5th percentile, respectively). Structural constraints of *angkot* microbus, i.e. existing cabin dimensions that are not able to be altered immediately, as well as seat design guidance and practices from [35], were also considered. The constraint may force other design variables to be tuned. Lastly, most updated anthropometric data for Indonesian population from [30] was set as reference since the new design targets mostly Indonesians.

TABLE II
BODY GROUP LOADING ASSUMPTION FOR RULA ANALYSIS

	Body Group A Loading (Arm, Twist)	Body Group B Loading (Neck, Trunk)
Muscle Use	Mainly static, e.g. held for longer than 1 minute	Mainly static, e.g. held for longer than 1 minute
Forces and Loads	< 2kg intermittent load	< 2kg intermittent load
Arm Support	Arm supported	N/A
Legs and Feet: Seated. Legs and feet well supported; Weight even		

III. RESULT AND DISCUSSION

A. Video Observation

Ten variations of sitting postures were obtained from a one-day pilot study. In addition to these 10 postures, we added one classification and marked it as "other" for housing postures that did not fit any of the 10 postures (see Appendix 1). Data collected from three-day observation was deductively extracted by applying five-minute time-sampling strategy, yielding the frequencies for each sitting posture. Five postures that appear most often were chosen for further modeling and analysis in JACK software, i.e. posture no. 1 (11.33%), no. 2 (5.33%), no. 3 (18.67%), no. 9 (44.67%), and no. 11 (10.00%). Meanwhile, the frequencies for each remaining posture were recorded below 5 percent (0.00% for posture no. 4 and 8; 1.33% for posture no. 5; 3.33% for posture no. 6 and 7). Since posture no. 11 is unidentifiable; it was excluded, leaving the four remaining postures for further modeling and analysis.

B. Cabin and Seating Dimension Measurement

Measures of *angkot* cabin dimensions and seating arrangement were successfully collected, as seen in Table 3 for details.

TABLE III
MEASURES OF CABIN DIMENSIONS INCLUDING SEATING (IN MILLIMETERS)

	Cabin	Seating	
		Door Side (Left)	Right Side
Length	2190.00	1350.00	2100.00
Width	1390.00	320.00	320.00
Height	1230.00	310.00	310.00

C. JACK Analysis

The four remaining postures were modeled for both male and female mannequins. Appendix 2 points the details on joint angle values for each body part of the postures that produce reconstructed digital mannequin as seen in Figure 2, along with corresponding images from the observation. RULA was applied to evaluate each mannequin, and the results can be seen in Table 4. RULA scores of these postures fell into two categories i.e. “yellow,” which means “further investigation and possible changes are needed” and “red” that indicates “investigation and changes are required soon.”

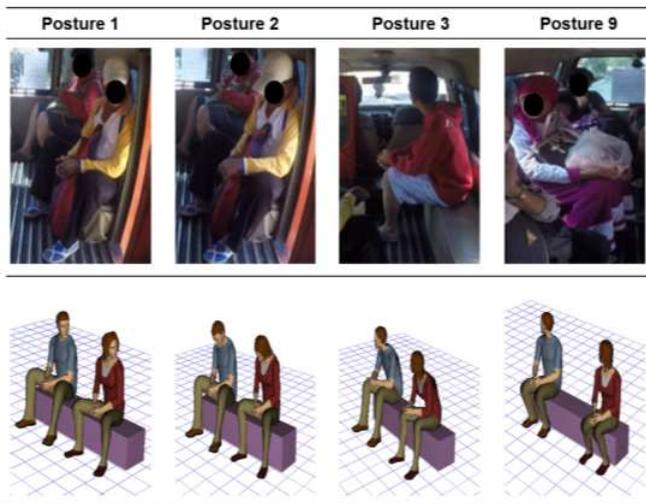


Fig. 2 Reconstructed human models in JACK

TABLE IV
RULA RESULTS FOR EACH SITTING POSTURE

Posture	1		2		3		9	
	M	F	M	F	M	F	M	F
<i>Body Group A Posture Rating</i>								
Upper Arm	0	0	0	0	2	2	1	1
Lower Arm	2	2	2	2	2	2	2	3
Wrist	1	1	1	1	1	1	2	2
Wrist Twist	1	1	1	1	1	1	1	1
Total	2	2	2	2	4	4	3	4
<i>Body Group B Posture Rating</i>								
Neck	2	2	3	3	3	5	2	2
Trunk	3	3	3	3	3	4	4	4
Total	5	5	5	5	5	9	6	6
Grand Score	4	4	4	4	5	6	5	6

D. Design Recommendations

Guided by the design principles, as mentioned earlier in this paper, the new design of *angkot* is proposed with radical changes appear in seating arrangements (Figure 3). Table 5 outlines dimensions used for variables of the design, such as

seat height, etc., including notes on several constraint adjustments. It is argued that a 48.67% increase in seating area can be claimed, comparing to left side seating area of pre-modified *angkot* design and 54.17% increase compared to right side sitting area. Table 6 demonstrates complete comparison between current and proposed new designs. In order to check whether the new design is suitable, an ideal sitting posture was reconstructed into digital mannequin, and JACK was rerun once again for doing RULA. The ideal sitting posture characteristics were taken from previous studies on front-facing sitting behavior that emerge in public transport vehicles, i.e. head/neck orienting front side with upright trunk [12]-[15], legs closing to each other [12], [14] and arm sustained [14]. Figure 4 illustrates the posture that most likely to emerge during travel in a vehicle with front-facing seats, including its corresponding RULA scores. The scores fall into “green” category, meaning that posture is “acceptable if not maintained or repeated for long periods.”

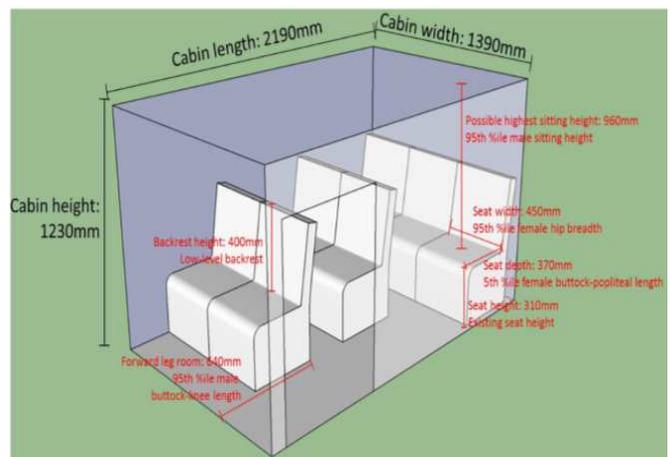


Fig. 3 Illustration of a proposed new design for *angkot*

E. Discussion

While previous studies have been conducted in related areas such as the ergonomics of sitting on trains [12]–[15], the behavior of traditional buses passengers in developing countries [2], [11], [22], [23], and aspects of Indonesian *angkot* minibuses such as public policy and economics [1], [16], [17], travel behavior [1], [19], [20], or safety [21], no previous work has looked specifically at the sitting posture issues faced by passengers of Indonesian urban minibuses (*angkot*). This is a particular problem given the prevalence of these modified minibuses, which result in a side-facing sitting posture. This study is believed to be the first to evaluate Indonesian urban minibuses, particularly concerning passenger sitting postures and the utilization of DHM software as an evaluating tool. Findings from this study could provide novel contributions to this particular research area and encourage the relevant authorities in Indonesia to take action to improve the available transport services.

The key findings of this study were postures that appear most often while passengers travel using *angkot*, i.e. no. 1, 2, 3, and 9 (see again Figure 2). Posture no. 1, 2, and 3 are similar about the head position, which is perpendicular laterally to the body (orienting sideward from its body orientation). Meanwhile, posture no. 2 was bowed (facing

downward). These findings are consistent with a previous study [4] that concluded that passengers tend to face towards direction of travel and, in some cases, facing down or bowed [15]. The undesired consequences for these bad postures, if maintained for long period, are muscle fatigue and postural stress in the neck [35] and increased risk of neck pain [36]. Another key finding of this study is that most people sit inside *angkot* with their upper limbs or trunk in an upright position, i.e. posture no. 1, 2, and 9. This corresponds with findings from [14], [13], [12], and [15] who reported that such position is widely observed among passengers inside public transport vehicles. Nevertheless, the study reported in this paper also found that sitting with bent-over back was also common (posture no. 3).

TABLE V
DIMENSIONS OF PROPOSED SEATING ARRANGEMENTS (MOSTLY ADAPTED FROM [35])

Variables	Relevant body dimensions	Proposed value	Note
Seat height	5 th percentile female popliteal height	310mm	Existing height is still in use for compensating structural constraint (1230mm); possible highest sitting height is used (960mm; 95 th male percentile); suggested dimensions (440mm; 5 th percentile female popliteal height) cannot be used as the highest possible passenger will struggle to sit properly.
Seat depth	5 th percentile female buttock-popliteal length	37 mm	-
Seat width	95th percentile female hip breadth	450mm	-
Backrest	-	40mm	Low level; compensating structural constraints and suiting more appropriately for general use of chairs than medium or high level.
Backrest angle	-	100 degree	The minimum angle, as suggested, is also compatible with low or medium-level backrest.
Forward legroom	95th percentile male buttock-knee length	64 mm	Or 270 mm if measured from seat's front edge.

TABLE VI
MEASURES OF SEATING AREA FOR CURRENT AND PROPOSED DESIGN (LEFT VS RIGHT SIDE; IN MILLIMETERS)

	Current Design		Proposed Design	% of Increase Compared to	
	Left	Right		Left	Right
Seat Depth	320.00	320.00	370.00	15.63	15.63
Seat Width	350.00 ¹	337.50 ²	450.00	28.57	33.33
Seat Height	310.00	310.00	310.00	0.00	0.00
Seat Area ³	112,000	108,000	166,500	48.67	54.17

¹. Σ left side length divided by the highest practical capacity (4 adults)

². Σ right side length divided by highest practical capacity (6 adults)

³. Seat depth multiplied by seat width (in mm²)

Concerning arm support while sitting, all postures appear in the observation were consistent with a previous study [14], that passengers tend to use their thighs to support their arms, along with the use of armrests. Identical leg positions were found among passengers, which fell to “free and both feet on floor” according to Branton and Grayson’s denotation (as cited in [14]). Since the seat height of an *angkot* is notably lower compared to common buses or trains (310mm from the floor), the knee angles of passengers were observed to be outstandingly less than 90 degrees, yielding a half-squatting posture. Thus, while the upright trunk observed in this study is not too different from other transport modes such as trains [12]–[15], the angle subtended at the hip is likely to be less, which may affect lower back comfort. With such a sitting position, the intervertebral disc pressure between the third and fourth lumbar vertebrae can reach 190%, compared to 100% during normal standing [37]. This circumstance might affect software judgment on trunk angles when performing RULA.

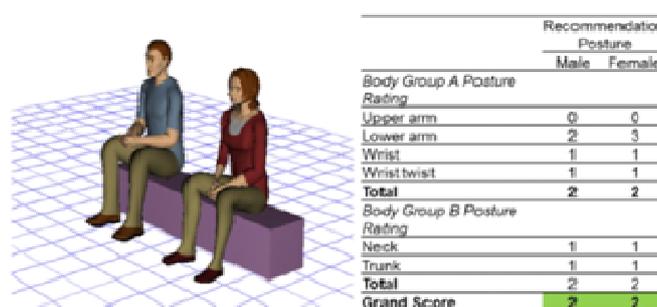


Fig. 4 Illustration of ideal sitting posture and its RULA scores

From JACK simulation, it was revealed that Body Group A consisted of arm and wrist yielded higher RULA scores than Body Group B (neck and trunk). Specifically, neck and trunk had high RULA scores in all postures (min=3 for trunk; min=2 for neck). The issue regarding the half-squatting position as previously mentioned was also confirmed by these results. RULA scores also indicate similarities between males and females for most postures. Female mannequin yields higher RULA scores than its male counterpart only in the lower arm and in the neck and trunk for posture no.9 and posture no. 3, respectively. The possible explanation for this is possibly related to proportional discrepancies of the length of upper and lower limbs between both sexes [35]. To put into a sitting context, a male mannequin having 172cm in stature can position his trunk more upright while putting his lower arms upon his thighs, whereas female mannequin seems to be difficult to achieve such position. Consequently, female mannequin with 159cm in stature has greater bending angle of her trunk than male mannequin while doing similar sitting position as she needs to lean forward to gain necessary support. In line with these issues, JACK simulation yielded “yellow” (posture no. 1 and no. 2) and “red” (posture no. 3 and no. 9) categories for respective postures, demanding to immediately investigate and change the current design.

Seeking for solution regarding the findings of this study, we attempted to propose design changes for *angkot*, seating arrangement in particular. Reference no. [4] serves as the primary reference to justify the suitability of front-facing

seats on the new design. Moreover, previously published guidance was considered [35], along with up-to-date anthropometric measures, design principles/strategies, and constraints when designing new seating arrangement of *angkot*. RULA scores from simulated sitting on the new seating arrangement indicate its relevance in minimizing harmful risks of passengers' upper limbs. The proposed design could also serve as a preliminary reference, while they are considered as solution to eradicate problem in neck area, in particular, reference no. [12] reported a potential homework for this design, that passengers sitting on front-facing seats still have a propensity to stare outside of the windows, which may warrant further investigation. However, front-facing seats are perhaps the best option for *angkot* to minimize the tendency of non-ergonomic postures and discomfort caused by direct stares of other passengers and acceleration sway [4].

Design correction related to spaces, e.g. shoes and clothing, as suggested in various literature [35] is actually worth consideration. However, due to before mentioned constraints, correction spaces seem to be not possible thus it was not considered in the proposed new design. The new design is already exceptionally compact in accommodating the extreme of Indonesian population. People whose body dimensions range outside the design limit (95th percentile or greater, in particular) will not be properly accommodated. Space allowances will be provided as long as the cabin is not full of 95th percentile people. That is, clothing allowances will inherently be provided when, for instance, a 95th percentile passenger is sitting next to a 50th passenger. Moreover, since temperature in Indonesia remains almost same throughout the year (average of 25°C in high mountain areas, 30°C in coastal plains), clothing allowances in Indonesia are presumably less than, for example, in the UK during winter.

Capacity reduction as the consequence of the new design, from 10-12 to 7 passengers, leads to some economic issue to which *angkot* owners and drivers may resist. This issue may hamper the implementation of the proposed seating layout as it directly relates to their daily earnings. Delivering complete notion on the urgency of safety and ergonomics aspects of *angkot* to affected stakeholders will become a great homework for relevant authorities.

This study inevitably has limitations to consider. For instance, we used only a single model of the bus and service line. In fact, there are varieties of minivans that have been modified as *angkot* microbus throughout Indonesian roads, serving divers urban routes. The more extensive scope of similar study is recommended in the future to achieve more vigorous data and better generalizability. About JACK software, validity of the digital mannequin or models would be potentially a threat to the validity of entire study, if not carefully considered. The issue arises from the fact that modeling humans to DHM software manually is prone to assessor or modeler subjectivity [38, 29]. Strategies to reduce, if not possible, to fully eliminate that subjectivity must be taken into account. This study, for instance, applied a simple strategy, involving inter-correction among authors. One of the most effective ways to increase validity in modeling humans into DHM software is taking the data of physical aspects, e.g. joint angles, head position, etc. from

comprehensive documentation [39]. However, such documentation seems to exist in a controlled environment such as in the laboratory. Having such detailed documentation for uncontrolled environment as in this study seems to be impractical.

Future study of similar phenomena is still wide-open to obtain a more thorough comprehension of *angkot* microbus. For example, as this study merely focused on sitting activity, future research can expand it to another activity of *angkot* passengers, such as boarding and alighting. We have known from this study that *angkot* is exceptionally dissimilar from any other form of buses in general. Thus, investigation towards boarding and alighting activities is both scientifically and practically interested. Further investigation may be able to evaluate its worthiness in emergency situation e.g. simulating evacuation of passengers or its feasibility in carrying people with special needs, e.g. disabled people or pregnant women. Varying methodologies for this kind of study may also be worth considering for validating present study or future expansion, by implementing self-report questionnaires regarding both physical and psychological comfort during travel using *angkot* microbus.

IV. CONCLUSIONS

This study showed that sitting postures that appear most often during *angkot* travel are sitting fairly upright, with the head facing down to the floor or facing front to the direction of travel; meanwhile, both arms are supported, and both legs are free on the floor. RULA scores generated from the JACK DHM simulation indicate that these postures are sub-optimal. It is therefore suggested that front-facing seats can be an option for replacing existing arrangement of seats inside *angkot*, which is more likely to be ergonomically better for passengers. The proposed design was demonstrated to minimize risk factors through a second JACK DHM simulation.

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APPENDIX I

Body parts	Posture no. 1	Posture no. 2	Posture no. 3	Posture no. 4	Posture no. 5	Posture no. 6	Posture no. 7	Posture no. 8	Posture no. 9	Posture no. 10	Posture no. 11	
Head/neck	Sideways	Down	Sideways	Front	Down	Front	Front	Sideways	Sideways	Front	Other	
Back/trunk	Relatively vertical (upright)	Relatively vertical (upright)	Relatively vertical (upright); leaned	Bent over	Relatively vertical (upright); leaned	Relatively vertical (upright); leaned	Other					
Arms	Supported (by thighs)	Supported (by thighs)	Supported (by thighs)	Right supported (by car structure); left supported (by thighs)	Right supported (by car structure); left supported (by thighs)	Right supported (by car structure); left supported (by thighs)	Supported (by thighs)	Supported (by thighs)	Supported (by thighs)	Supported (by car structure)	Other	
Legs	Angle < 90; separate/apart	Angle < 90; separate/apart	Angle < 90; separate/apart	Angle < 90; close	Angle < 90; close	Angle < 90; close	Angle < 90; close	Angle < 90; separate/apart	Angle < 90; close	Angle < 90 (left); > 90 (right); close	Other	
Images												N/A
Notes	The gentlemen in front	The gentlemen in front		The lady in front	The lady in front	The lady in the middle		The gentlemen in front	The lady in the middle			

APPENDIX II

Body Parts	Joints	Posture 1		Posture 2		Posture 3		Posture 9	
		Male	Female	Male	Female	Male	Female	Male	Female
Head	Axial twist Z	14.5	19	0	0	-33.5	-21.7	-26.5	-42.1
	Flexion/extension Y	-5.6	0	7.3	8	-34.6	-20.9	-0.6	-4.7
	Lateral bend X	-2.4	-4.9	0	0	7.3	8.8	2.7	1
Eyeball	Lateral rotation X	0	0	4.9	4.7	0	0	0	0
	Pitch Z	0	0	-15	-15	0	0	0	0
Neck	Flexion/extension Y	6.9	-1.1	26.4	28.4	14	-7.2	-3.4	-3.4
	Axial twist Z	54.9	54.9	0	0	-14	-29.2	-54.9	-42.2
	Lateral bend X	-1.7	-2.9	0	0	-0.8	2.5	5	4.5
Shoulder	Elevate	22.5	22.5	28.1	28.1	43.1	48.8	28.1	28.1
	Anterior/posterior	75	65.6	75	75	73.1	78.8	75	75
	Axial rotation	17.3	24.4	15	17.3	5.6	-8.4	15	17.3
Elbow	Flexion/extension Y	74	62.5	74	62.5	91.7	85.9	72.5	57.8
Wrist	Ulnar/radial deviation Y	0.9	9.4	0.9	9.4	0.3	1.8	11	11
	Flexion/extension X	5.6	-2.1	5.6	-2.1	5.6	6.3	-1.2	-1.2
	Pronation/supination Z	-27.9	-33.8	-27.9	-33.8	-27.3	-30.1	-21.5	-21.5
Hand	<i>Predefined 'neutral.'</i>	<i>Predef.</i>							
Torso	Flexion	27	27	27	27	41.8	54.6	38.9	38.9
	Axial rotation	-2	-2	-2	-2	-2	-2	0	0
	Lateral rotation	1.1	1.1	1.1	1.1	1.1	1.1	2.8	2.8
Pelvis	Forward/backward rotation Z	90	90.3	90	90.3	90	90	90	90
	Lateral rotation	162	164.6	162	164.6	162	162	150	150
	Twist	-3.1	-1	-3.1	-1	-3.1	-3.1	0	-0.1
Hip	Internal/external rotation Z	1.6	0.6	1.6	0.6	3.4	1.3	5.3	9.1
	Adduction/abduction X	29.2	23.3	29.2	23.3	16.3	12.1	8.8	2.9
	Flexion/extension Y	96.1	86.3	96.1	86.3	86.3	78.8	68.2	65.4
Knee	Flexion/extension Y	105.8	105.8	105.8	105.8	93.9	90.3	122.2	120.6
Ankle	Adduction/abduction Z	7.7	7.7	7.7	7.7	4	4	-0.9	6.6
	Inversion/eversion X	8.8	4.2	8.8	4.2	0.3	0.3	-3.5	-7.4
	Flexion/extension Y	-7.7	6.5	-7.7	6.5	-9.9	-4.4	23.9	23.9
Toe	Flexion/extension Y	0.2	0.2	0.2	0.2	0	0	0.2	0.2