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Can Youth Reach Agricultural All-Terrain Vehicle Controls?

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ABSTRACT. *All-terrain vehicles (ATVs) are popular among children for recreational and occupational purposes. However, the increase in vehicle power, size, weight, and speed has made these machines unsafe for youth. A recent study revealed that riders younger than 16-years old accounted for 25% of ATV-related injuries on American farms. Moreover, several researchers identified a correlation between ATV-related injuries of children and their readiness to ride, which mainly comprises anthropometric dimensions and physical strength. Therefore, it is hypothesized that youths are frequently involved in ATV-related incidents because they ride vehicles that are unfit for them. There is a need to assess the fit of Agricultural ATVs for children based on youths' anthropometric dimensions. This study focused on evaluating potential inconsistencies between the operational requirements of utility ATVs and the anthropometric measurements of youths through virtual simulations. A numerical computing software was used to assess four youth-ATV reach criteria proposed by an ATV safety advocacy organization (National 4-H council). In total, 14 utility ATVs and male children of three different ages (8, 12, and 16 years old) and three body-size percentiles (5th, 50th, and 95th) were evaluated. Preliminary results demonstrated a physical mismatch between utility ATV operational requirements and anthropometric dimensions of children. The simulations involving children under the age of 12 years old (50th percentile) indicated that they are not able to activate the hand brake of the evaluated ATVs properly. On the other hand, the simulations with 16-year-old males showed that only a small percentage (33%) of the ATVs have enough room for the riders' legs. This compromises riders' ability to steer the handlebar and control the vehicle. These discrepancies compromise youths' capability to ride utility ATVs, placing them at an increased risk of injuries.*

Keywords. *Anthropometric dimensions, ATV, Crashes, Ergonomics, Incidents, Youth.*

Introduction

All-terrain vehicles (ATVs) are popular among children for recreational and occupational purposes, especially in the agricultural sector (Jennissen et al., 2014). According to a survey among U.S. rural households, children are now more likely to have ridden an ATV than a tractor (Goldcamp, Myers, Hendricks, Layne, & Helmkamp, 2006). However, the increase in vehicle power, size, weight, and speed has made the operation of these machines unsafe for young operators (Murphy & Harshman, 2014). A recent report revealed that riders younger than 16-years old accounted for 25% of all ATV-related injuries in the U.S. (CPSC, 2018).

A number of researchers identified a relationship between ATV-related injuries of children and their readiness to ride, which mainly comprises anthropometric dimensions and physical strength. In addition, one previous study demonstrated that ATV-rider misfit is an important risk factor (Bernard et al., 2010). Nevertheless, some of the most common ATV riding guidelines (ANSI/SVIA, 2017; CPSC, 2006) disregard the rider's physical abilities.

It has been hypothesized that youths are frequently involved in ATV-related incidents because they ride vehicles that are unfit for them. There is a need to assess the fit of Agricultural ATVs for children based on youths' anthropometric dimensions. This study focused on evaluating potential inconsistencies between the operational requirements of utility ATVs and the anthropometric measurements of youths through virtual simulations.

The present study aimed to compare children's anthropometric dimensions with operational requirements from utility ATVs, based on reach criteria proposed by the National 4-H Council (National 4-H Council, 2005). The study provides critical evidence that contributes to the scientific basis for modifying regulatory/advisory guidelines and state and national policies for operating utility ATVs.

Material and Methods

Study Overview

This study focused on the physical ability of male youths to reach and activate ATV controls while maintaining a safe posture. An operator's inability to reach a control while maintaining a safe posture would place operators and potential bystanders at risk.

Fourteen utility ATVs were evaluated in this study. Selected ATVs consisted of vehicles of varying makes, models, sizes, and mileages, from the most common vehicles utilized by American farmworkers (Honda, Yamaha, and Polaris).

Data Collection

A Virtual reality (V.R.) tracking technology (Vive – HTC Corporation, China) was used to take measurements from the selected ATVs. The V.R. tracking device can collect a given point's coordinates in a three-dimensional (3D) space. A comprehensive description of installing and using the V.R. system to track objects' spatial coordinates can be found in Kreylos (2016). The spatial coordinates of the following ATV features were collected with the V.R. tracking device: ATV seat reference point, footrests, handlebar handles, foot brake pedal, and hand brake lever.

Youths' Anthropometric Dimensions

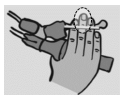
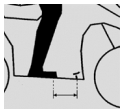
The anthropometric dimensions of youths were retrieved from the public dataset of Snyder et al. (1977), which includes measurements from 3900 subjects from 2 to 18 years of age for both genders.

Some of the anthropometric dimensions required for computing youths' capabilities of reaching ATV controls were not available in the database used for this study, such as shoulder breadth, seated shoulder height, arm length, etc. For those cases, the missing inputs were computed using the available data. For example, the shoulder breadth was assumed the same as the biacromial breadth; the seated shoulder height was calculated by subtracting the head and neck length from the seated height; the arm length was assumed the same as the acromion-fingertip length.

Reach criteria

The reach criteria considered in this study were selected based on the recommendations of the National 4-H Council (National 4-H Council, 2005). The reach criteria are illustrated in Table 1 below.

Table 1 – Youth-ATV reach guidelines

I.D.	Criterion		"Fit success"
1	Handlebar-knee distance		Handlebar–knee distance > 200mm. This is necessary to ensure that the rider can reach the handlebar and steer around obstacles.
2	Hand size compared to ATV brake grip size		With hand placed in the normal operating position and fingers straight out, the first joint from the tip of the middle finger extends beyond the brake lever. This is important to guarantee that the rider can activate the brake lever.
3	Brake-foot position		Distance from the "ball" of the foot (at its most rearward position in the ATV's foot well) to the brake pedal divided by the length of the foot < 105%. A disproportional rate indicates a risk for ineffective foot brake operation.
4	Footrest reach		Riders must be able to keep their feet firmly on the footrests when not activating the foot-brakes. This is important to ensure the rider can maintain balance and don't lose control of the ATV.

Data Analysis

The primary results consist of distances between several ATV controls and youths' corresponding anthropometric dimensions. A numerical computing software (Matlab v2020a, Mathworks, Natick, MA) was used to evaluate youths' corresponding anthropometric dimensions concerning the reach criteria proposed by the National 4-H council. This study assessed male youths aging from 8 to 18 years old, from three body-size percentiles (5th, 50th, and 95th).

The suitability of ATVs to riders (binary dependent variable) was determined based on potential mismatches between the reach criteria (independent variable), the distances between ATV controls (independent variable), and youths' corresponding anthropometric dimensions (independent variable). In other words, a youth must be able to "succeed" in all four criteria for a specific ATV for that vehicle to be considered "suitable to the specific youth as a rider."

Results

In this study, 14 ATV models were evaluated from three manufactures (Honda, Yamaha, and Polaris). Around 72% of the vehicles being assessed were brand new, whereas 80% (n = 4) of the remaining ATVs were classified in either good or excellent condition. Engine capacity range was from 200-700 cc, with most vehicles in the range of 400-500 cc (50%). Moreover, the evaluated ATVs had 4 wheel-drive (86%) or 2-wheel drive (14%), rear axle - solid bar (50%) or suspension system (50%), and manual transmission (93%) or automatic transmission (7%).

The percentage of ATVs with operational requirements exceeding youths' physical capabilities is presented in Table 2. The results indicated that criteria 1, 2, and 4 are the main limiting factors for youths riding utility ATVs. On the other hand, the data showed that the foot brakes (criterion 3) do not represent any limitation for young operators. Lastly, the data showed that older youths conform better to some criteria while younger youths conform better to some others. Thus, there is a need for redesign of utility ATVs to better fit young operators or to review and refine age limitations for ATV operation by youths.

Table 2 – Percentage of observations with operational requirements exceeding youths' physical capabilities for different reach criteria

Age		8			12			16		
Percentile		5th	50th	95th	5th	50th	95th	5th	50th	95th
Handlebar-knee distance		4%	8%	17%	17%	33%	67%	33%	67%	87%
Hand size compared to ATV brake grip size		58%	54%	46%	50%	46%	17%	46%	17%	4%
Brake-foot position		0%	0%	0%	0%	0%	0%	0%	0%	0%

Footrest reach		75%	46%	12%	21%	4%	0%	4%	0%	0%

The inability to depress the hand brakes (criterion 2) affects the rider's ability to reduce the speed or stop the ATV. In addition, the inability to freely steer the handlebars (criterion 1) or maintain control of the vehicle (criterion 4) affects the rider's ability to divert from obstacles. These disabilities placed young operators at an increased risk of incidents.

Conclusions

This study evaluated the potential mismatches between youths' anthropometric dimensions and the operational requirements to safely operate fourteen utility ATVs. The main findings were:

- Most youths do not conform to the fit criteria proposed by regulatory agencies;
- There is a need for redesign of utility ATVs to better fit young operators or to review and refine age limitations for ATV operation by youths;
- The present study provides quantitative and systematic data to support the establishment and refinement of policies and guidelines related to youth-ATV operations to reduce injury events caused by physical mismatches.

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