Scales Feature Foot Scanners as Parameters of Flat Feet in Children

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***Abstract*— The primary function of the legs is to provide the necessary support and encouragement for human bipedal movements. Flat feet or also known as pes planus, is a problem that is often encountered in daily pediatric practice for most children. This study aims to classify the shape of the soles of the feet in children aged 6-9 years to be divided into three parts, namely high arch, normal arch and flat arch. Clarke's angel is defined as the angle obtained by a tangent that joins the medial edge of the first metatarsal head and the heel, on the second line connects the metatarsal caput one with the centre of the longitudinal arch of the medial side. Of the 30 children, 66.67% (20 students) had a flatfoot foot shape and 33.33% (10 students) had a normal foot sole shape and none of the students had a cavus arch foot sole shape. The mode in children with normal legs is Enough with a percentage of 60% and in children with flatfoot is bad with a percentage of 75%. This proves the relationship between flatfoot and static balance in children. From the research we conducted, it can be concluded that the featured scales we made can capture the image of a child's feet to identify flat feet and the relationship between flat feet and the static balance of a child. From the research that has been carried out, we compare existing data using three methods. The primary method we use is Matlab software with comparison data using wet footprints and stork stand tests, which shows excellent accuracy and can be a reference for measuring the soles of the feet in the future.**

***Keywords*___ Flat foot in children, scale feature foot scanner, image processing, wet foot print test, arch index**

I. INTRODUCTION

A Flat foot is a condition in which the absence of a medial longitudinal arch of the foot causes part of the sole of the foot to stick to the ground [1]. A flat foot is a condition of curvature on the inside of the sole of a flat foot (flat arch) so that when standing, most of the sole touches the anvil [2]. Previous studies [3] looked for correlations between flatfoot and static and dynamic equilibrium. In female respondents, 20 children had normal arches (60.6%), and 13 had flat foot conditions (39.4%). In contrast, in male respondents, out of a total of 18 respondents, it was recorded that 8 children had normal arches (44.4%) and 10 children were in flat foot conditions (55.6%). A study [4] also looked for a correlation between flatfoot and delayed walking. Of the 120 children, 41 (34.2%) suffered from pes planus, while 11 (9.2%) had a history of delayed walking. Of the 11 children, 9 people experienced pes planus. Most children with pes planus have a degree I (78%). However, these studies still use the wet footprint method and have not used special tools for footprints.

Clarke's Angel in the journal has a statistically significant correlation between the navicular fall test and the footprint parameter (r = – 0.643), followed by Staheli index (SI) (r =0.633) and Chippaux-Smirak index (CSI) (r =0.614) [5]. The footprint parameters studied are reproducible and thus have excellent reliability. Clarke's Angle method is calculated by measuring the angle of two lines. The first line is to connect the medial edge of the metatarsal caput one with the heel than on the second line connects the metatarsal caput one with the center of the longitudinal arch of the medial side, the parameters for Clarke's Angel are normal foot 31° to less than 45°, flatfoot less than 31°, cavus foot more than 45° [6].

The wet footprint test, achieved by wetting the feet in the water and then standing on a flat surface such as fine concrete, thin cardboard, or heavy paper, is a simple and conventional home diagnosis. The wet footprint test method is carried out by placing the soles of the feet soaked in ink or paint on plain paper. Then the pedis arches were identified using Clarke's angle method [7]. Static balance check using Stork Stand Test. Respondents were asked to stand upright, shoulder-width apart, with their hands on their waists. When instructed, the respondent raised one leg and placed it on the inside of the knee of the other leg while closing his eyes. Respondents were asked to maintain balance and not to lower their legs or move them to support. Use a stopwatch to record the time since the patient raised his legs and closed his eyes until he lost his balance [6].

This study uses image processing which consists of thresholding is one of the image segmentation methods that separate objects and backgrounds in an image based on differences in the level of brightness or dark light [8]. The following process of segmentation that is, imagery, can be formulated as a pixel classification problem with semantic labels (semantic segmentation), partitioning of individual objects (segmentation of instances), or both (panoptic segmentation) [9]. The point plotting stage is carried out after segmentation to determine the point of the binary number line to be drawn. The last stage, the transposition of a matrix, is obtained by converting rows into columns. For example, row one becomes column one, and row two becomes column two, and so on. The data we took for this study were images of the soles of the feet and the wet stamps of the soles of the feet. The method of taking the image data of the soles of the feet is that the subject stands on the scales we have provided. A webcam connected to a PC/Laptop will take a picture of the soles of the feet. The subjects in our study were grade 1 elementary school students at SDN Pendrikan Lor 01

II. MATERIAL AND METHOD

A. Design, Manufacture and Testing of Tools

The stage in making feature scales is to make a tool design. First, the design of the featured scale tool can be seen in fig. 1 material used is a weight scale with a maximum capacity of 150 kg and an Aukey PC-LM1E webcam with a maximum resolution of 192 x 1080 pixels. The scale's base uses teak wood and iron poles 25 cm long. The material that has been combined is then tested before taking it on the subject. Testing the tool was tested on grade 1 elementary school children, and the results of the test got a good and exact image of the soles of the feet and wet footprint results.

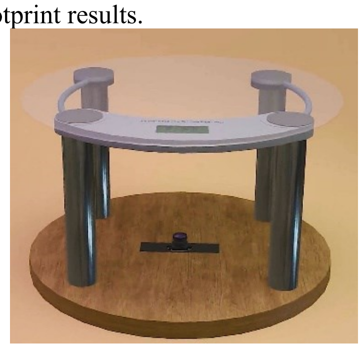

Fig. 1 Feature Scale Design

B. Taking Images of the Soles of the Feet

Testing of featured weighing tools image capture of the soles of the feet is carried out on grade 1 elementary school children with an age range of 5-9 years. Subjects are directed to line up and then climb the scales one by 1 to take an image of the soles of their feet. It can be seen in fig. 2 that children process the subject climbing the scales to take an image of the soles of the feet. The process of capturing images of the soles of the feet takes a short time, which is less than 1 minute. This process also uses a webcam as a tool to capture images of the soles of the feet.

Fig. 2 Testing of Featured Weighing Tools

C. Selection of Good Image

The image selection process in question is selecting the image of the soles of the subject's feet when a webcam takes the image. This aims to select good image quality so that when processing, the soles of the feet do not have much noise.

D. Image Processing

The image processing stage goes through several stages. The first is Thresholding, where the process, based on the difference in the degree of imagery, separates the object from the background in an image based on the difference in the level of brightness or the light darkness and changes the colour of the image to black and white. The second stage is Segmentation. This program separates the object (foreground) from the background. The output of the image segmentation results is binary, namely, 1 when white (object) and 0 when black (background). The third stage of Estimation of Pixels in Reference is a program to identify each existing pixel into a value. The fourth stage of Scale Conversion is to confer between two different sizes, starting the conference from pixels to centimetres to facilitate processing for Clarke's angel method measurement. The formula used to determine the degree angle of the sole is in equation (1). The fifth stage is plotting points to determine the point of the binary number line that will be carried out by drawing the foot edge line, leg length, and foot width to perform Clarke's Angel angle calculations. The last stage is Transpose, turning rows into columns to simplify the image processing process. which can be seen on the fig. 3 Is an image of the process from image processing until the results of Clarke's Angel method lines and the degree of foot arch are obtained. Fig. 4 shows stages in image processing.

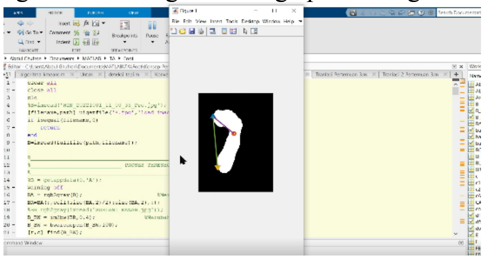

Fig. 3 The Result of the Image of the Soles of the Feet With the Method of Clare's Angel

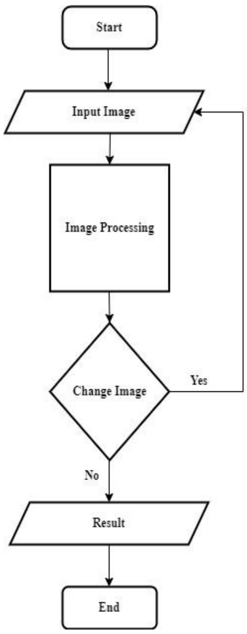

Fig. 4 Flowchat Stages of Image Processing

Processes in fig. 4 Explain that the image is inputted, and then image processing is carried out. After that, if there is a change in the image, then the process is repeated from the stage of entering the image. If not, the process can go directly to the next stage, displaying the results. If the results are appropriate, then the process is complete.

E. Stand Stork Test

A static balance check is carried out after taking an image of the soles of the subjects' feet. The subject is asked to stand upright, shoulder-width apart, with the subject hands at the waist. When instructed, the subject lifts one leg and places it on the inside of the knee of the other leg while closing the subject eyes. The tool for calculating the time since the patient raises his legs and closes his eyes until he loses his balance is a stopwatch. Fig. 5 Explaining how to stand to perform a static balance test on subjects. The figure also refered to a journal of [5]

Fig. 5 Tools Stork Stand Tes

Table I explains the reference time to determine the assessment of the static balance of the subject.

TABLE I
STORK STAND TEST

	Category	*Men*	*Women*
1	Very Good	> 51 sec	> 28 sec
2	Good	37 – 50 sec	23 – 27 sec
3	Enough	15 – 36 sec	8 – 22 sec
4	Less	5 – 13 sec	3 – 6 sec
5	Very Less	0 – 4 sec	0 – 2 sec

*sec for second

F. Wet Footprint Test

A wet footprint test is a test by attaching the sole to a coloured liquid, then the sole is attached to the paper. This research uses natural dyes made from dragon fruit for the paper used, namely millimetre block paper. Millimetre block paper is done to facilitate the calculation process using Clarke's Angel method by drawing two lines at 2 points. Fig. 6 shows the shape of the soles of the child's feet that have been carried out a wet footprint test.

Fig. 6 Wet Foot Print Test

G. Calcification of Children's Soles

This process is the final stage of the study. The classification of the soles of the feet is the process of determining the shape of the soles of the feet of the subjects, including the normal form of an arch, high arch or cavus arch. Determination of this classification by looking at the results of image processing which are compared with the results of the wet footprint test and strengthened by the results of the stork stand test.

III. RESULT

Of the 30 respondents, 10 children had normal foot (33.33%), 20 children had flatfoot (66.67%), and none of the students had a cavus arch foot sole shape, as written in Table II. This result was obtained from the image of the foot captured on the footprint scale and the image data processed in MATLAB.

TABLE II
FEATURED SCALE MEASUREMENT RESULTS

Sole Type	**Number of Subjects**	**Gender (Male/ Female)**	**Clark's Angel**	
			Range (°)	**Average (SD)**
Normal	10	3/7	12-30	5,6273143
Flat Foot	20	20/6	31-41	3,6055512
High arch	0	0/0	0	0

Table III shows the results of the data on the wet footprint test. The results on the wet footprint test show the same number in children with normal leg shapes, flatfoot and high arch. The difference is only in the degree of the soles of his feet. This is because the size of the sole on the wet footprint test produces a value that is greater than the size of the sole from the image on the footprint scale.

TABLE III
WET FOOTPRINT TEST CALCULATION RESULTS

Sole Type	**Subjects**	**Gender (Male/ Female)**	**Wet Footprint**	
			Range (°)	**Average (SD)**
Normal	10	3/7	12-30	5,8547327
Flat Foot	20	20/6	31-42	3,7555392
High arch	0	0/0	0	0

Table IV shows the Stork Stand Test results to test the respondents' static balance. We separate the time classification of the stork stand test based on normal foot shape and flat foot to see if there is a correlation between the child's foot shape and their balance status. The mode in children with normal feet is Enough with a percentage of 60% and in children with flatfoot it is bad with a percentage of 75%.

TABLE IV
STORK STAND TEST MEASUREMENT RESULTS

Sole Type	Category	Subjects	Stork Stand Test
			Percentage
Normal	Very Good	1	10%
	Good	0	0%
	Enough	6	60%
	Less	2	20%
	Very Less	1	10%
Flat Foot	Very Good	0	0%
	Good	0	0%
	Enough	3	15%
	Less	15	75%
	Very Less	2	10%
	Very Good	0	0%

From the table above results, it is stated that the soles of the feet that do not have a normal shape will interfere with a person's balance. A person with a flat foot condition experiences weakness of the intrinsic muscles of the foot as a longitudinal arch support structure that can affect the lever component of the body during foot strikes and push-offs to disrupt one's balance [6]

IV. CONCLUSIONS

From the results of this study, it is stated that footprint scales can produce images of the soles of the feet that can be processed to identify the shape of the feet, flatfoot, and high arch. It can be seen that the standard deviation in each experiment is the same, namely 3.3166, and for flat foot, there is a difference of 0.1%, which indicates that from the three attempts, the error that occurred was tiny but judging from the standard deviation of the high arch in the stork stand test experiment was very different because the time used was one of the factors of the other two comparisons. However, it did not affect the results at all.

Previous research on flatfoot detection in children still uses wet footprint tests to take images of the feet' soles [10]. Some studies look for correlations with static equilibrium but still use wet foot tests in flat foot detection methods [6]. Meanwhile, research that discusses the development of the wet footprint test still uses a scanner with a resolution of 200 pixels per inch [11]. Meanwhile, this study uses scales that are used in addition to measuring weight and a footprint tool. The purpose of this feature scale tool is to be used in health centres when checking the health and detecting the shape of the soles of children's feet.

Our study aims to correct the weaknesses of the wet foot test method that some hospitals still use to determine the shape of flatfoot or high arch soles. Footprints with wet foot tests are inaccurate because, in addition to the difficulty of knowing the sufferer is standing upright when printing the soles of the feet and the possibility of not printing some parts of the soles of the feet due to uneven initial painting of the soles of the feet [11]. This tool relies on images captured by the webcam to produce images of the soles of the feet, where the proper lighting and room conditions are needed. With it, the image of the captured sole will be clear and can be processed on the program in MATLAB. The disambiguation of the degree of the arch of the sole using Clarke's Angel method used in Matlab as in the study below [12].

$$Clarke's\ Angle = cos^{-1}\left(\frac{S^2 - T^2 - F^2}{-2TF}\right) \quad (1)$$

Where T is calculated by iterating, in forefoot and hindfoot, pixel by pixel from right to left to find the pixel (t1) closest to the starting point in both areas. The S line is calculated by drawing a line from the outer point on the front foot (t1) to the inner point of the middle leg (s1). The F line moves from the outer point of the hind leg (f1) to the inner point of the middle leg (s1).

When compared to the wet foot test method, our study produced better results. The sustainability of this study is to create footprint scales that can capture images in each room condition and different lighting and create a real-time system for detecting the shape of the soles of the feet (normal / flatfoot / high arch). The results of this study can be used as a technology for the early detection of flat feet in the future

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