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The Development And Testing Of Automatic Crutches For Disable Person

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ABSTRACT – Walking aids such as canes, crutches, and walkers play a crucial role in improving a patient's base support, balance, and independence. However, conventional crutches with manual height adjustment mechanisms pose challenges for users, especially on uneven surfaces, leading to device damage and incorrect height settings. To overcome this issue, this paper introduces a crutch design that incorporates an automatic height-adjustment feature tailored to the patient's individual height. It utilises a linear actuator for height adjustment and soft materials for padding. To assess its functionality and effectiveness, a comprehensive evaluation is conducted, comparing the proposed automatic crutch to traditional axillary crutches. Experimental results demonstrate that the innovative device facilitates enhanced mobility on uneven surfaces, aids in climbing stairs, and offers personalised comfort for sitting or standing. Moreover, the cushion pad integrated into the design effectively reduces friction and pressure between the armpit and crutches, thereby mitigating the risk of armpit injuries. This research signifies a significant advancement in walking aid technology, addressing critical issues associated with manual adjustment and improving the user experience using crutches.

KEYWORDS : Crutches, Disable Person, Walking aid, Balance.

1.0 INTRODUCTION

Disability and mobility challenges often increase with age. While walking aids such as canes, crutches, and walkers offer a means to enhance a patient's support base, improve balance, and promote increased activity and independence, they come with substantial musculoskeletal and metabolic demands. Unfortunately, many patients using walking aids lack proper instruction, leading to the use of inappropriate, damaged, or incorrectly sized devices. Choosing the right aid hinges on considerations such as the patient's strength, endurance, balance, cognitive function, and environmental requirements [1].

Complications arise when individuals, whether short-term or long-term users, incorrectly employ crutches and encounter difficulties related to the materials used in the devices. Despite clinical recommendations for the injured or disabled to employ crutches for walking, a significant portion of individuals remains uninstructed on their proper usage. Alarmingly, up to 70 percent of canes are found to be faulty, damaged, or incorrectly sized. Studies reveal that the majority of patients acquire their walking aids independently or based on suggestions from family and friends, with only a third obtaining devices through medical professionals. Moreover, a mere 20 percent receive proper education on usage [2].

Assessment of mobility aids highlights prevalent issues, including devices being the incorrect height (often too high), suboptimal material for padding, and poor maintenance, featuring loose rubber caps or hand grips. These challenges significantly impact users, emphasizing the critical need for widespread education and awareness to enhance the effective and safe utilization of walking aids [3].

Ensuring the correct length of crutches is vital to teaching proper crutch walking techniques. If too short, patients may slouch, while excessive length can exert pressure on the axilla [4]. Traditional axillary crutches further pose risks, transmitting jarring forces to the wrists and shoulders and potentially causing injuries to the user. A prevalent issue among crutch users is crutch palsy, where the outer edge of the crutch saddle damages nerves in the axilla, impairing nerve conduction and leading to total or partial paralysis in the arm and hand muscles.

Crutches are mainly used for lower leg injuries or illnesses that require non-weight bearing. Most people use non-weight-bearing crutches when they need to keep weight off an injured leg so they can heal and get back to full mobility. Non-weight-bearing crutches can be used for both short- and long-term mobility assistance and can help to support your weight when you are unable to do so on your own. There are many injuries that require crutches, such as tendon ruptures, broken ankles, foot fractures, stress fractures, and many others. The purpose of crutches is to provide more weight support so as to improve nearly all of the weight on the affected limb. The amount of weight the crutch can support depends on the type of crutch used.

The axillary crutch is designed to support the most weight, followed by the forearm crutch and platform crutch. Another important use for crutches is to give those who would not normally be able to walk by themselves the ability to do so. The crutch assists upright movement and transmits sensory cues through the hands. People with partial paralysis benefit from crutches because they promote upright posture and allow them to move through places they might otherwise not be able to access with a wheelchair. The health benefits of regaining upright body movement through the use of crutches are quite positive; they include improved circulation, assisting kidney and lung functions, and helping prevent calcium loss from bones [5].

In contemporary times, crutches serve as invaluable devices for individuals experiencing mild leg weakness or pain. However, the manual adjustment mechanism of traditional crutches can be time-consuming and pose challenges, particularly for users lacking cognitive or physical abilities to promptly modify the crutch height before walking. Additionally, conventional axillary crutches prove challenging for individuals with disabilities when navigating slopes, steps, and uneven terrain, necessitating frequent height adjustments based on their specific needs. To overcome the this issue, this paper proposed an automatic crutches for disable person.

The remaining sections are arranged as follows-: section 2 briefly discusses the methodology of the proposed devices including the project development and data collection, section 3 discusses the experimental design of this work. Section 4 concludes to this paper.

2.0 METHODOLOGY

In this project, the automatic crutches are developed to make the user easy to use and comfortable when using the crutches. This device includes a power switch to turn it on or off. When the device is already turned on, the user who has no ability or wants to adjust the height on uneven ground can use the switch button to either increase or decrease the crutches. The linear actuator is used as a function to retract and extend the crutches, depending on the height that the user wants to adjust. The linear actuator, push button to control the height of the linear actuator, and switch to on or off the device are used in this project, which is connected with Arduino software to control the whole device.

Besides, the battery is used in this project to make the device portable and can be used anywhere. The battery used is a 12V supply, and it can be recharged. The user can charge the battery to make the device operate safely. In order to develop a comfortable device other than the easy-to-adjust height of the crutches, the design of the crutch pad is changed by using foam cushion material. The material is more comfortable to reduce fatigue, soreness, and rashes under the arm when the users use the crutches.

2.1 Project Development

In this project development, the innovation to be added to the crutch hardware will be the use of an automatic system for extension and retraction of the crutches. It is because the existing axillary crutches are manually adjusted by the patient. So, if using the automatic crutches, the user will easily press the button to adjust the height of the crutches without using more energy. The motor used can also support the weight or size of the person who uses the crutches. The normal pad for crutches will also be replaced by a foam cushion in the new design to reduce pain, friction, and cushion stress against the user's chest. As it continues to retract and extend, the process will pursue a similar flowchart that appeared in Figure 1, and Figure 2 shows the block diagram of the system of automatic clutches.

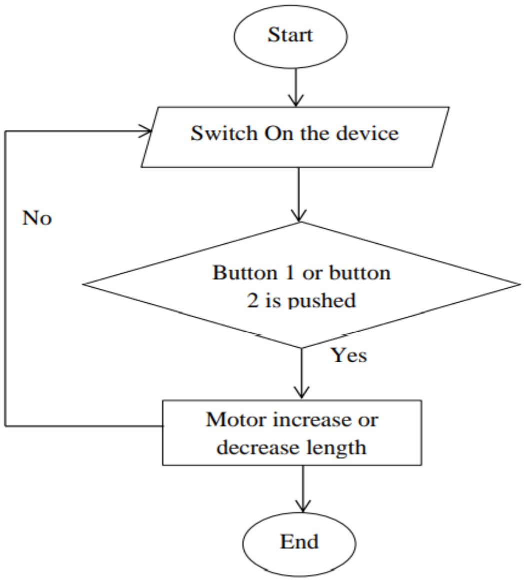

Figure 1. Flowchart of the Automatic Crutches

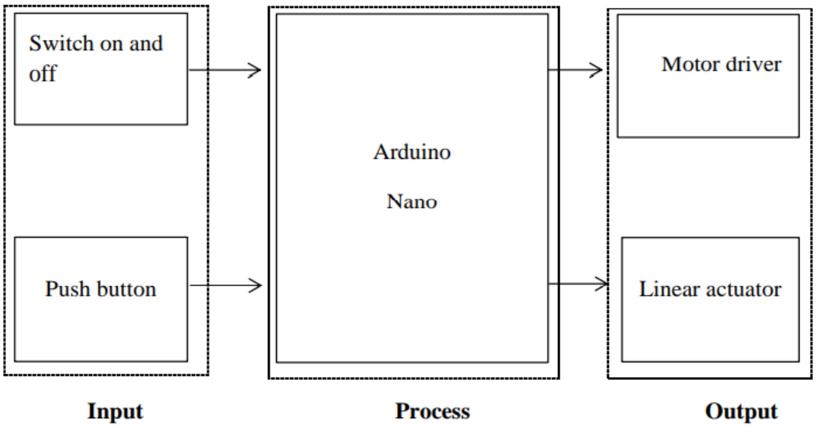

Figure 2. Block diagram of the system of Automatic Crutches

2.2 Data Collection

Spatiotemporal gait analysis was conducted in 5 healthy people, 1 man and 4 women. The study inclusion criteria were the following: 5 selected normal subjects, age over 20 years until 70 years, ability to walk at least 4 m without stopping without crutches, with manual axillary crutches and with automatic crutches. All participants gave their informed consent before the procedure was performed. The investigation was governed by the ethical principles for human experimentation. All patients were analyzed while walking without crutches, with manual axillary crutches, and with automatic crutches.

To avoid possible differences derived while walking, especially when using the crutch, the patient was instructed to first walk with the crutch on one side only. In consequence, two recordings were made in each test for every patient for the time taken: normal walking, walking with manual crutches, and walking with automatic crutches. The measurement of the data for the three spatiotemporal parameters step length, stride length, and cadence is shown in figure 3.

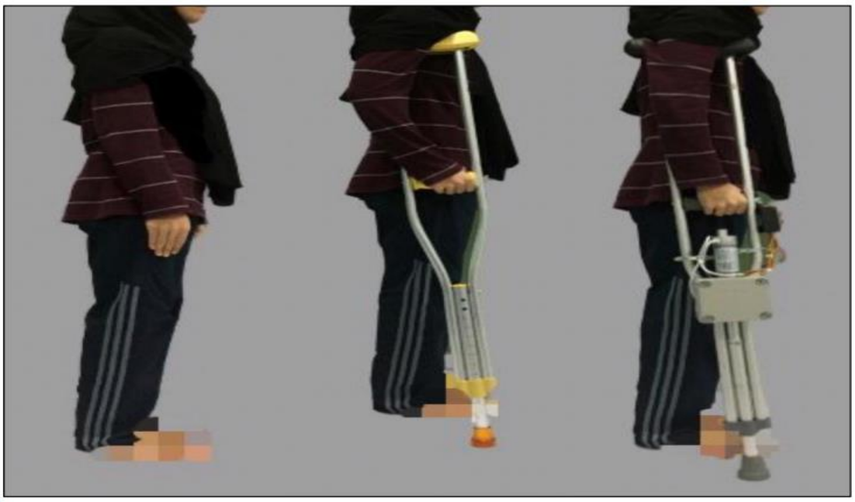

Figure 3. Subject for the three spatiotemporal parameter condition: step length, stride length and cadence

The parameters of step length are measured using the distance between two consecutive heel strikes, while for stride length, it measures the distance between two consecutive heel strikes by the same leg, and the cadence is the number of steps taken in a given time, usually steps per minute. The detailed measurement is shown in Figure 4.

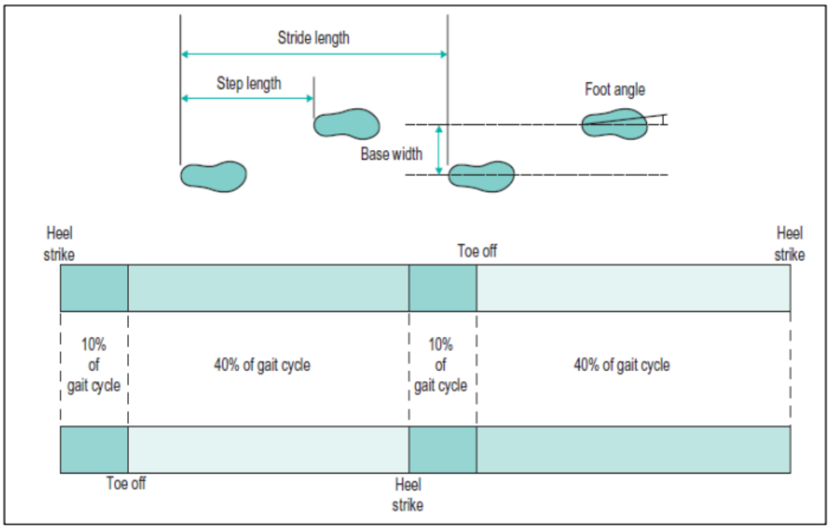

Figure 4. Step length and stride length measurement.

While for the cadence, it refers to the number of steps taken per unit of time, typically measured in steps per minute (spm).The formula for cadence given as,

$$Cadence\ (steps/min) = \frac{Cadence\ (steps/min)}{Times\ (sec)}$$

3.0 RESULT

This section discussed the performance of proposed devices in three different condition. There are normal walking gait, walking gait without manual crutches and walking gait with automatic crutches. The discussion is based on the three parameter which are step length measurement, stride length measurement and cadence. The measurement performance are tabulated as in Table 1. Based on the table, performance of subjects using automatic crutches closely mirrors that of a normal walking gait in terms of step length, with noteworthy exceptions for Subject 3 and Subject 5. This suggests that, for most subjects, the automatic crutches effectively replicate the natural step length observed during normal walking. Similar to step length, the stride length measurement for walking with automatic crutches closely aligns with normal walking gait for the majority of subjects, except for Subject 5.

This implies that the introduction of automatic crutches generally maintains a gait pattern consistent with unconstrained walking. The cadence, or step rate, in the walking gait with automatic crutches remains closely related to the normal walking gait across all subjects. This is a crucial finding, indicating that the proposed of automatic crutches does not significantly disrupt the rhythmic aspect of walking.

From the comprehensive analysis presented in Table 1, it can be conclusively stated that walking with automatic crutches tends to provide gait values very close to those observed in normal walking. This suggests that, when set to an appropriate height, automatic crutches contribute to the stability of subjects during walking, allowing them to achieve gait patterns comparable to those of individuals without crutches. This finding underscores the potential of automatic crutches as a means to enhance mobility and replicate a more natural walking experience for individuals requiring such assistive devices. Further research and individualized adjustments may provide additional insights into optimizing the performance of these automatic crutches for a broader range of users.

Table 1. Subjects perfomance for normal walking gait, walking gait without manual crutches and walking gait with automatic crutches.

SUBJECT	PARAMETER	Normal walking gait	Walking gait with manual crutches	Walking gait with automatic crutches
SUBJECT 1	Step length	37.1	39.1	30.9
	Stride length	65.8	72.3	62.8
	Cadence	71.43	66.47	70
SUBJECT 2	Step length	25.7	14.8	23.7
	Stride length	57.1	37.6	47.9
	Cadence	100	100	100
SUBJECT 3	Step length	20.3	15.9	10.5
	Stride length	45.8	35.7	34.7
	Cadence	100	66.67	100
SUBJECT 4	Step length	38.6	20.7	28.6
	Stride length	74.9	56.1	59
	Cadence	85.71	66.67	70
SUBJECT 5	Step length	56.3	41.8	36.3
	Stride length	109.5	93	88.2
	Cadence	85.71	75	75

4.0 CONCLUSION

In conclusion, the developed prototype of automatic crutches, equipped with soft padding for enhanced support, proves to be a successful innovation catering to the mobility needs of partially or entirely disabled individuals. Notably, our findings indicate a substantial disparity between the walking patterns of subjects using manual crutches compared to those using automatic crutches, showcasing the latter's closer approximation to normal gait values. This discrepancy emphasises the importance of advanced assistive tools, such as automatic crutches, in achieving more natural and stable walking patterns. The successful operation and easy adjustment of crutch length by users during trials underscore the practicality and user-friendliness of the developed prototype. Moreover, our investigation verifies that the crutch mechanism functions as expected, aligning with the predefined design requirements.

Throughout testing, the automatic crutches effectively accommodated a diverse range of test subjects, weighing between 40 kg and 70 kg. Although variations in the speed of the linear actuator were observed based on different weights, the prototype consistently demonstrated its capability to raise or lower individuals within the desired maximum load capacity of 700 N. This versatility in accommodating various weights positions the automatic crutches as a promising solution, particularly given their absence in the current market or medical industries. In essence, the successful development and testing of the automatic crutches prototype mark a significant advancement in assistive devices, offering a viable and efficient solution for individuals with mobility challenges. Further refinements and potential commercialization could contribute to the broader accessibility of this innovative technology in improving the daily lives of individuals with mobility impairments.

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