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# Evaluating mobility and access of disabled refugees in Rohingya camps in Cox's Bazar

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**Abstract:** To better understand the mobility needs of Rohingya refugees with physical disabilities, specifically lower limb impairments, members of the Mobility Aid project team visited Rohingya refugee camps in Cox's Bazar, Bangladesh. Interviews and gait analyses with 14 participants were conducted over a three-week period in September 2021. Interviews covered topics such as the origin of disability, barriers and challenges associated with physical disability in refugee camps, and disability-related discrimination. Participants were also asked about ways in which they adapt and compensate for physical disabilities in challenging environments. An analysis of these findings is presented to highlight the need for emergency and humanitarian response planning to include persons with disabilities. In addition, the team conducted gait analysis from videos obtained using a simple inexpensive setup and remotely evaluated six disabled participants. The preliminary results of this gait analysis are promising and comparable to the patterns observed in the lab settings.

**Keywords:** Rohingya refugees, disabilities, mobility, access, gait analysis.

## 1. Introduction

The Rohingya have faced decades-long persecution from the Myanmar government. A Muslim ethnic minority living in the western Rakhine State of Myanmar, the Rohingya are considered to be one of the most victimized populations in the world. The Rohingya have had their citizenship revoked, are not allowed to vote, and the Myanmar government has strict laws regulating the Rohingyas' ability to work, marry, and own property. Starting in 2017, the Myanmar army began a new violent campaign against the Rohingya population living in Rakhine State after clashes with alleged Rohingya militants. Fleeing rape, torture, physical violence, and murder, over one million Rohingya refugees have relocated to neighboring Bangladesh [1].

Refugees under any circumstance face tremendous obstacles, but these challenges are amplified for refugees with disabilities. It is estimated that 15% of the world's population lives with some form of disability [2] and that people with a physical disability are two to four times more likely to be killed or injured in natural disasters [3]. Priddy [2]

identifies persons with disabilities (PWDs) as “the forgotten victims of armed conflict.” Sexual and gender-based violence (SGBV) also disproportionately impact those with disabilities [4].

Mobility concerns for Rohingya refugees with physical disabilities are especially pressing in refugee camps in Bangladesh – most notably the Cox’s Bazar area. This area is prone to monsoons, cyclones, and flooding; all of which contribute to landslides. Muddy, steep, and unstable terrain in these camps makes movement between shelters and facilities near impossible for refugees with physical disabilities [5].

To address the mobility challenges faced by Rohingya refugees with physical disabilities, partners from SUNY Korea, Arizona State University – Tempe, Hellenic Mediterranean University, and Youth Power in Social Action (YPSA) Bangladesh have come together to design an alternate crutch/cane shoe/tip. With a wider surface area and more flexible material, the alternate crutch shoe is better suited to the terrain of refugee camps. The alternate crutch shoes are produced using a combination of 3D printing a mold and pouring silicon rubber into the mold to manufacture on-site shoes for the replacement of existing crutch shoes. Remote gait analysis using OpenPose software identifies unique joint movements to help evaluate the performance of the alternate crutch shoe [6].

Creating a better understanding of the intersections of physical disability and forced displacement, medical care, aid access, safety, and inclusion requires intense consultation with those directly impacted by physical disability. Through interviews with Rohingya refugees with physical disabilities, the Mobility Aid project team is able to better tailor their services to fit specific needs.

## **2. Research Method**

In this paper we examine three related research questions:

RQ1 – In Cox’s Bazar, what are the primary concerns around mobility for Rohingya refugees with physical disabilities?

RQ2 – What are the other challenges disabled Rohingya refugees face in Cox’s Bazar camps?

RQ3 – Are the camps’ healthcare services sufficiently inclusive and accessible for the Rohingya refugees?

In order to answer these three questions our methodology combines both qualitative and quantitative data from video analysis and interview data to better understand obstacles disabled and injured refugees face.

Data collection occurred in September 2021 when one of the main investigators from Mobility Aid team traveled to Cox’s Bazar, Bangladesh to conduct interviews with Rohingya refugees with physical disabilities. These interviews were conducted with the assistance of YPSA over a period of three weeks. Fourteen Rohingya refugees, reported ages seven to 106 (self-reported), were asked questions about the origin of their disability, barriers, and challenges related to their disability, existence of possible disability-related discrimination, and ways in which they adapt and compensate for physical disability.

It is to be noted that, due to COVID-related restrictions, movement within the camp areas has been significantly restricted, which made things even more challenging for people with disabilities. In order to make things a bit easier for the interview respondents, the interviews were centrally conducted in two different community centers, where the local partner YPSA provides healthcare services for the refugees. Senior respondents were assisted by the YPSA volunteers to traverse through the hilly terrains to attend the interviews. YPSA volunteers also helped as interpreters. The Rohingya language does not have any official alphabet and none of the respondents had English or Bengali literacy. Hence at the start of each interview, the volunteers communicated to every respondent about the goal of the study and the ethical measures the research project is taking to ensure their privacy. Interviews commenced after the respondents provided their verbal consent.

One way to access mobility is evaluating gait, which is a manner or style of walking. In the case of people walking with crutches enhancing their gait stability is paramount for their survival in inhospitable terrains. Gait analysis is typically based on sophisticated instrumentation measuring body movements, body mechanics and activity of the muscles. Assorted studies have been carried out using different tools such as force platform, optical markers and 3D-cameras. These motion capture systems are expensive and must be installed in appropriate rooms containing expensive equipment. In addition, these systems require installation in areas with sufficient space and a specialized technician is also required to properly operate the system [7].

The Mobility Aid team developed a new approach recording video obtained using two simple mobile phone cameras from six participants who walked 3 times each. The cameras were positioned as to provide a stereoscopic view of the participant’s walking with crutches, with one camera recording the side view of the walk and the second camera, at 90 degrees to the first camera, recording the participant from the front view. The two cameras were calibrated using a large checkerboard pattern to obtain the stereoscopic transformation matrix, which was used to obtain the 3D position data of an object in the covered area. This non-contact and low-cost data collection was then evaluated and subsequently used to calculate Signal-to-Noise-Ratio (SNR) of acceleration and jerk, which is the first derivative of acceleration, for the ankle of each participant. This approach is building upon previous work of the Mobility Aid team [6,8] on evaluating and verifying the approach applied to the gait of disabled people who walk with crutches in the lab environment in South Korea where the principal investigator works.

This was the first attempt to collect data directly from the field with disabled or injured Rohingya refugees. To gain a better understanding of the challenging terrain of the refugee camps in Cox's Bazar, Mobility Aid team members toured camps, documented different paths frequently used by the respondents and other people with physical disabilities, and visited the homes of five respondents. The team furthermore talked with the relatives, neighbors, and aid workers, who are closely involved with some of the respondents' daily lives in order to develop a comprehensive understanding of the latter group's mobility challenges.

The IRB approval for this study has been obtained from the organization where the principal investigator of the Mobility Aid project works, and it follows the Declaration of Helsinki and its set of ethical principles.

### 3. Results

In this section qualitative results of interviews are presented separately from the quantitative results of gait analysis. The integration of those results is presented in the discussion section.

#### 3.1. Qualitative data results

Interviews with Rohingya refugees with physical disabilities were conducted in keeping with Mobility Aid's mission to "improve the mobility of people with disabilities in navigating environmental obstacles in [these] limited-resource settings" [9]. Fourteen respondents were interviewed of which 13 were male and one was female. Nine of the 14 respondents reported their cause of injury or disability as violence from the Myanmar army. The Rohingya population in Rakhine State, Myanmar has been subjected to "generations of statelessness and marginalization, extreme violence" and forced displacement [10]. The nine respondents who reported their cause of disability as violence from the Myanmar army were shot or beaten. Delay of medical care necessitated lower limb amputations for some respondents as wounds had become infected without treatment. In the words of one of the respondents (male, 30 year old):

*"The Burmese Army shot me, but I could not stop running. We walked and ran for several days before crossing the border. By the time I reached Bangladesh, my leg was already in very bad shape from the bullet wound's infection. They (the doctors) had to cut it, but I survived!"*

Two of the respondents reported their disability resulted from accidents – one respondent was hit by a vehicle in the refugee camp and another sustained significant injury to his back and legs in a landslide. An additional two respondents reported their cause of disability as an unspecified congenital abnormality or birth defect and the final respondent stated their mobility challenges stemmed from an exacerbation of secondary medical conditions.

Respondents detailed a variety of challenges regarding the intersection of their disability and navigating life within refugee camps - one of the most reported issues being difficulty with the surrounding terrain. The Rohingya refugee camps in Bangladesh are frequently located in areas with steep environments and landslides and flooding from rain are common [11]. One respondent reported specifically avoiding leaving his home when it was raining, and another reported complete avoidance of any area with inclined terrain. Difficult terrain acts not only as a physical barrier to refugees with disabilities but a social and resource barrier as well. As one respondent (male, 40 year old) mentioned:

*"During the rainy season, I just cannot go outside. Sometimes I am stuck at home without anything. But it's impossible to walk in such a muddy terrain with my physical condition."*

Respondents described the difficulties encountered when accessing food and other resources and aid items. Many reported hiring other refugees (camp porters) within the camp to carry aid items for them or to assist them in moving about the camp. Some respondents pay for these services through selling their aid items or by trading items for service. Respondents reported experiencing both exploitation and theft – primarily through having their aid items or money stolen by camp porters. It is well-documented that people with disabilities are at increased risk of experiencing physical and sexual violence and that this risk is increased in humanitarian settings [12]. The exploitation of people with disabilities through theft is itself a form of violence. As one of the senior respondents (male, 62 year old) described:

*"It happened with me several times. I trusted people who offered help to carry my food relief. As soon as they get my food packets, they disappear. With my condition, there is no way I could keep up with them. My family and I end up being hungry."*

The lack of appropriate medical care or lack of accessible medical care in refugee camps was also reported to be a challenge by the respondents. Further medical issues have arisen from the lack of appropriate medical care and from broken or improperly used mobility devices. Several respondents reported developing sores and infections in their armpits from defective or mismatched crutches. One respondent received surgical intervention for a leg injury from an unspecified NGO. By the time the respondent was ready for follow-up surgery, the NGO was no longer working within the camp. Seemingly simple barriers such as replacing a missing screw for a crutch present significant obstacles as the whole crutch must be replaced. Vendors within the refugee camp do not sell the required replacement screws.

In addition to physical concerns surrounding their disabilities, respondents also relayed concerns regarding social issues. The two respondents under the age of 18 reported concerns around isolation from schooling and peers. The people with disabilities who are most impacted by isolation and loneliness are young adults who are "economically inactive, living

in rented or other accommodation, and have low levels of access to environmental assets” [13]. This group is heavily represented in Cox’s Bazar and among the entire Rohingya refugee population in Bangladesh.

Concerns regarding disability-related discrimination were reported by one participant. They reported what they described as “intense discrimination” from medical providers. It is unclear if there is a cultural difference in how discrimination is experienced, if respondents were reluctant to report discrimination, or if discrimination against refugees with physical disabilities is not as prevalent as predicted. It also must be considered that Western perceptions and assumptions about discrimination against people with disabilities are being wrongly imposed.

### 3.2 Results of Gait Analysis

The synchronized videos from the two phone cameras were combined into a 3D representation of the participant’s walk. With the help of machine learning algorithms of Open Pose, the participant and points on their body were identified and the coordinates in space of their movement with time were calculated. From the spatial information, kinematic parameters, such as velocity which is the rate of change of displacement with time; acceleration which is the rate of change of velocity with time; and jerk which is the rate of change of acceleration with time, were calculated for the ankle of the disabled participant.

As the participants were dressed in loose clothing it was not possible to accurately estimate the movement of the Centre of Gravity of the body, as it is frequently done in gait analysis with multiple video cameras. In the present case, points on the body such as the ankle were followed, as they can be identified clearly by the software and their spatial position can be calculated with far smaller error than the Centre of Gravity.

In addition, in conventional gait analysis, the individual phases of each step are calculated, but in this work, the study focused on the overall walk of the participant, which consisted of several steps during the video. In this work, the stability of the walk is assessed from the complete movement of the participant, as it is assumed of being more representative of the abilities and performance of the disabled person.

For the gait analysis, the Rohingya participant group consisted of six disabled people, with one of them being an amputee, while all of them were long-term users of crutches. The gait analysis metrics calculated were the Signal-to-Noise-Ratio of the kinematics of their ankle for the duration of the video. The subset of five long-term Rohingya crutch users, where the amputee was excluded, showed a consistent SNR of acceleration and jerk with a difference of 2% between the calculated SNR of the acceleration and jerk of the walk of each participant. The amputee Rohingya participant showed a much larger difference of 5% between the SNR of acceleration and jerk, with that of the jerk being lower than that of the acceleration. This qualitative difference has been observed previously with an experienced long-term crutch user of the early study of gait performed in South Korea whose difference was far larger. In South Korea, participants included long-term crutch users who were disabled of poliomyelitis, inexperienced short-term crutch users with no disability, and experienced long-term (because of injury from an accident) crutch users with no permanent disability. Out of these, an experienced long-term crutch user stood out for his stability and confidence in his walk. These observations were obvious in his videos, were identified in the gait analysis performed on the walk and were also confirmed in the subjective questionnaire used as well. This reference South Korean participant showed a difference between the SNR of acceleration and jerk for each of his three videos taken, which was also the case for the three videos taken for the Rohingya amputee participant.

It should be emphasized that high SNR values correlate with a better performance, which in this case relate to smaller abrupt changes to acceleration, while lower SNR values relate to higher abrupt changes to the rate of change of acceleration, or jerk. Therefore, in this case, the two participants, the Rohingya amputee, and the South Korean long-term crutch user showed a consistent, in all three runs, high SNR of acceleration, with a confident and strong movement in their walk. At the same time, they showed a consistent, in all three runs, distinctly lower SNR of the rate of change of acceleration (i.e., jerk) as they had rapid changes in acceleration in order to move in space as they desired. They were, in effect, more in control of their movement even though it required abrupt changes in the movement of the ankle to walk confidently. This quantitative observation seems correlated with how confident and strong crutch users are. It appears that the other five Rohingya crutch users are less confident which could be a consequence of them using crutches for a shorter time.

Figure 1 shows the front view and Figure 2 the side view for one of the disabled participants using customized crutch shoes produced by the Mobility Aid project team.



**Figure 1. Front view of participant's walk**



**Figure 1. Side view of participant's walk**

#### **4. Discussion**

Rohingya living in Myanmar have experienced decades of violence and dispossession. This violence does not always end once Rohingya refugees reach a host country or community. Refugees with disabilities are at increased risk of violence and exploitation and the lack of needs assessments based “on disability or specific vulnerability” leaves this population in a precarious situation [10]. Because of data disaggregation, a true understanding of the scope of disability among Rohingya refugees has not been obtained. Reports vary on the prevalence of disability, ranging from 3-14%, and reports have differing inclusion and exclusion criteria [14]. What is clear, however, is the overwhelming need for disability-related services in all humanitarian aid responses and especially for Rohingya refugees in Bangladesh.

A 2021 REACH report on age and disability in the Rohingya refugee response revealed that 76% of refugees with physical disabilities reported difficulty with mobility in refugee camps, 64% reported challenges accessing food and other aid services, and over 50% reported being unable to access medical services. For those able to access medical services, many did not get the appropriate care or there were no services for those with physical disabilities [15]. These reports mirror the responses of refugees interviewed by Mobility Aid and underscore the need for disability-inclusive and accessible medical services.

In lower resource settings, physical disabilities are often compounded by malnutrition, diminished access to WASH facilities, and the absence of rehabilitation facilities. Mobility Aid works to offset these factors by providing mobility assistive devices that adhere to concepts of usage such as physical availability, financial affordability, and acceptability [9]. Future research regarding refugees with physical disabilities and assistive technology should be inclusive of this framework.

Following a need for financial affordability, the current study is proposing a simple, inexpensive, non-contact, remote evaluation of stability in crutch users, something not done before. Typically, a standard gait evaluation measures body kinematics, muscle activity, and body mechanics using sophisticated instruments. All the studies that are measuring gait have been conducted using high-end tools including force platforms, 3D cameras, and optical markers. These advanced

systems require installation in specialized spaces and are prohibitively expensive for limited-resource settings. In addition, a trained technician is necessary to properly operate the system [16]. To our knowledge, there has been only one exploratory study assessing stability by measuring the acceleration of the people who use crutches [17], and that study looked at periodic patterns while using sensors and optical motion capturing of participants.

The COVID-19 pandemic has suspended much on-the-ground research and continues to impact the ability of humanitarian actors to provide needed services. Therefore, remote assessment is a valuable addition accessing mobility of disabled refugees. Future and more elaborate study of mobility technology and Rohingya refugees with disabilities should be completed so Mobility Aid team members can continue to provide appropriately tailored services.

## 5. Conclusion

This paper presented a case study of Rohingya refugee camp and results of data collection by Mobility Aid team. Mobility Aid team works in collaboration with the local Bangladeshi NGO, YPSA, to support Rohingya refugees with physical disabilities, specifically lower limb impairments. The data collected during a visit during September 2021 by one of the investigators for Mobility Aid includes interviews with 14 Rohingya refugees with physical disabilities and video data of 6 participants. The data from the videos has been used to compare gait of the refugees who walk with crutches with the lab results and the conclusion was that is produced comparable results. This gives the team conformation that they can remotely monitor gait of disabled refugees. Qualitative data indicates that the difficult terrain is not only a physical barrier to refugees with disabilities but a social and resource barrier as well. Among many frustrations of this population are some simple barriers such as replacing a missing screw for a crutch since vendors in the camp do not sell the required replacement screws. Finally, very few respondents report discrimination, so it appears that the discrimination against refugees with physical disabilities is not as prevalent as expected.

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