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ORIGINAL RESEARCH

Experts' opinion on manual wheelchair adjustments for adults with diabetes

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ABSTRACT

Diabetes is a global health concern that can lead to mobility limitations necessitating a wheelchair. However, there are currently no guidelines for wheelchair adjustments tailored to the diabetic population.
Purpose: To describe relevant manual wheelchair adjustments for adults with diabetes, and to explore how these adjustments apply to populations living in less-resourced countries.
Methods: Semi-structured interviews were conducted with 13 wheelchair experts from five different countries working with adult with diabetes. Interviews were analyzed using the constant comparison method.
Results: The most frequently mentioned wheelchair adjustments were related to neuropathies, skin integrity, decreased strength and amputations. Air cushions were preferred for managing seat sores. Lightweight wheelchairs could be advantageous for people with decreased strength and endurance. In less-resourced settings, wheelchair adjustment decisions prioritized durability and low maintenance.
Discussion: The recommendation of lightweight wheelchairs for adults with diabetes may be limited by the lack of adjustment possibilities compared to regular weight wheelchairs. In less-resourced settings, prioritizing durability and low maintenance may limit prevention and management of conditions associated to diabetes.
Conclusion: This study represents a first step towards the development of guidelines for manual wheelchair adjustments specifically tailored to adults with diabetes, in a global health context.

➤ IMPLICATIONS OF REHABILITATION

- When prescribing manual wheelchairs to persons with diabetes, expert clinicians agree that skin integrity, neuropathies and decreased strength are their primary concerns.
- Compromises are often necessary when adjusting a wheelchair for a person with diabetes, due to the complexity of their symptoms: same modification can be indicated for one symptom but contraindicated for another.
- Diabetes prevalence is high in less-resourced settings. There is a need for increased availability of affordable wheelchair equipment that is durable, reliable and adapted to persons with diabetes.

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Wheelchair adjustments; guidelines; diabetes; expert opinion; qualitative research

Introduction

Diabetes is a major global health concern. Currently, 387 million people around the world have diabetes, and this number is expected to rise to 592 million by 2035 [1]. Low- and middle-income countries host 77% of all cases [1]. The increasing incidence of diabetes has been strongly associated with aging of the population in less-resourced countries, as well as increased westernization and urbanization [2,3].

Complications commonly associated with diabetes include obesity, arthritis, vision loss, hypertension, heart disease and stroke, kidney disease, peripheral arterial occlusive disease, diseases related to the nervous system and cognitive decline [4–7]. For example, excess weight and obesity is associated with 90% of all cases with type 2 diabetes [3]. Furthermore, neuropathies are present in 60–70% of people with diabetes and may result in pain, incontinence and impaired sensation [4,8]. The latter, which affects the feet in nearly 30% of diabetics who are over 40 years old, can lead to unnoticed injuries related to minor traumatic events, friction or overpressure. These injuries, combined with a reduced blood flow, can lead to skin ulcers, which can have serious consequences, namely amputation of the foot or the lower-limb [6,9,10]. Indeed, skin ulcers and other complications related to diabetes account for over 60% of non-traumatic lower-limb amputations [4], and are more common in less-resourced countries where access to healthcare and education on diabetes self-management are limited [9,11]. In 2014, the cost of care for diabetic foot ulcers was estimated at $1.5 billion, annually [12].

People with diabetes are 2–3 times more likely to experience functional limitations, as a consequence of amputations, decreased cardiopulmonary reserve or visual impairments [5]. Mobility aids such as manual wheelchairs (MWC) are generally recommended, when mobility is impaired due to lower-extremity amputation or limited endurance. MWC components need to be appropriately selected and adjusted based on the user's needs. Poor MWC adjustments have been linked to MWC abandonment, diminished health status and increased healthcare costs [13,14]. In 2013, the World Health Organization published a comprehensive guide for MWC service and training, which stresses the choice of

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Supplemental data for this article can be accessed here.

Table 1. List of wheelchair parts used as probes during the interviews, to the question: "Which manual wheelchair parts will you consider adjusting for a patient with diabetes?".

Padding/protectors (e.g., Tube protection)	Seat cushions (air, gel, foam, profiled)	Handrims	Spoke/finger guards
Arm supports	Postural support device	Foot supports, stump support	Lower leg support
Rear wheels (position, size, etc.)	Casters	Anti-tip bars	Frame (rigid, folding)
Axle	Seat	Back support (angle, type)	Brakes

appropriate wheelchair components based on the user's abilities, lifestyle and environment [15,16]. While these guidelines do not directly address diabetes, they provide detailed solutions for some of the conditions associated with diabetes; for example, persons with lower-limb amputation require the MWC's wheels to be moved back to compensate for the shift in the body's centre of gravity. The choice of cushions to alleviate pressure sores is also addressed. However, the WHO wheelchair reference manual does not provide any guidelines on some of the other conditions associated with diabetes, such as impaired vision and sensory loss. In addition, individuals with diabetes can present with many associated conditions, which may create an additional challenge for the final choice of MWC components and their adjustments. For example, increasing the MWC's tilt angle can diminish seat pressure, which is important to prevent skin ulcers, but this can also decrease visibility and increase the strength required to propel the MWC, which may be contraindicated if the user also has decreased endurance and visual loss.

In terms of the scientific literature, MWC parts have been broadly described, as well as the overall pros and cons of various designs [13,17–21]; however, research is largely lacking in the linking of these designs with specific health conditions. Wheelchair adjustments and clinical guidelines have been described for specific populations such as spinal cord injuries and traumatic brain injuries [14,22,23], but not for the adult diabetic population. Furthermore, with the increasing diabetes epidemic and associated amputations in less-resourced countries, there is a need for low-cost solutions adapted to regional realities. Indeed, in less-resourced countries, MWC prescription and adjustments present with their own challenges due to limited resources and local accessibility issues, such as rough terrain [24].

Therefore, the main objective of this study was to identify and describe the clinical reasoning underlying important MWC adjustments for adults with diabetes through the gathering of expert opinions. A secondary objective was to explore how these adjustments applied to populations living in less-resourced countries. This information is a critical first step towards the development of MWC prescription guidelines specifically tailored to the diabetic population, within a global health context.

Methods

Experts' opinions were gathered through semi-structured interviews with healthcare professionals providing MWC services to adults with diabetes. All participants were fluent in French or English, and interviews were conducted in the language of their choice (French or English) in person, by Skype or by phone between May and June 2015. Consent forms and questionnaires were also available in both languages. Interpretive descriptions were used to develop clinical reasoning through the research of patterns and themes relevant to clinical settings [25]. This research is based on a constructivist paradigm.

Recruitment

Healthcare workers with right of practice in their country were recruited through convenience and snowball sampling if they met the following inclusion criteria: a minimum of three years of experience related to MWC provision, previous experience prescribing MWC to individuals with diabetes, working primarily with adults, having the ability to communicate in either English or French. The criteria for minimum years of expertise was selected based on other studies that have gathered expert opinion for understanding wheelchair needs and developing wheelchair skills and seating assessments, that have used values ranging from 2 to 5 years [26–29]. All participants read and signed a consent form approved by the *Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal* (CRIR) ethics committee.

Data collection and measures

Each participant underwent a 30–45-min semi-structured interview either in person, by Skype or by phone, recorded with the participant's permission. Interview guidelines were constructed based on a literature review and a chart review of recent adult clients who were prescribed a MWC mainly due to diabetes or its associated conditions at the *Constance Lethbridge Rehabilitation Centre* in Montreal. Interview questions addressed the participants' experience and clinical reasoning about MWC prescription and adjustments for adults with diabetes. Clinicians were first asked an open-ended question on what MWC adjustments they would consider for a client with diabetes. This was followed by systematic probes related to the conditions most frequently associated with diabetes; for each such condition (Table 1), participants were asked which MWC parts should be adjusted and how (Table 1). Participants were also asked to suggest MWC adjustments for less-resourced settings, which elicited discussion on their lived experiences in these settings.

Data analysis

A constant comparison method [30] was used to analyze the data as it was collected. The coding process for each transcript was performed independently by two researchers, who compared their responses and came to a common agreement. The initial codebook was built using an Excel spreadsheet, based on the first two interviews, discussed and agreed upon within the team of researchers. Themes and categories were then refined as the analysis progressed. Themes were separated into two broad categories: diabetes associated conditions, and MWC adjustments in less-resourced settings.

Trustworthiness and rigor

Throughout the research and analysis process, an audit trail was documented to allow for researchers' self-reflection, and to facilitate reproducibility of the study. Interview guidelines were reviewed by an expert clinician working in the field of MWC provision in order to ensure face validity [31]. Training was then provided to the interviewers through practice interviews to ensure quality results [32]. To allow for thorough coverage of all topics and for observations from various viewpoints, each interview was carried out by two researchers working in pairs. Paraphrasing, reflective listening during interviews and member checking were

Table 2. Demographic table of participants' characteristics.

Participants	Occupation	Region	Experience in less-resourced settings	Years of experience in wheelchair delivery services
1	Occupational therapist	North America	None	20
2	Wheelchair technician	North America	None	25
3	Occupational therapist	North America	None	12
4	Occupational therapist	North America	None	12
5	Occupational therapist	Australia	Yes	15
6	Physical therapist	Africa	Yes	25
7	Wheelchair technician	Australia	Yes	3
8	Occupational therapist	North America	None	6
9	Occupational therapist	North America	Yes	8
10	Occupational therapist	North America	None	8
11	Physician	South America	Yes	10
12	Physical Therapist	South Asia	Yes	6
13	Physical Therapist	South Asia	Yes	6

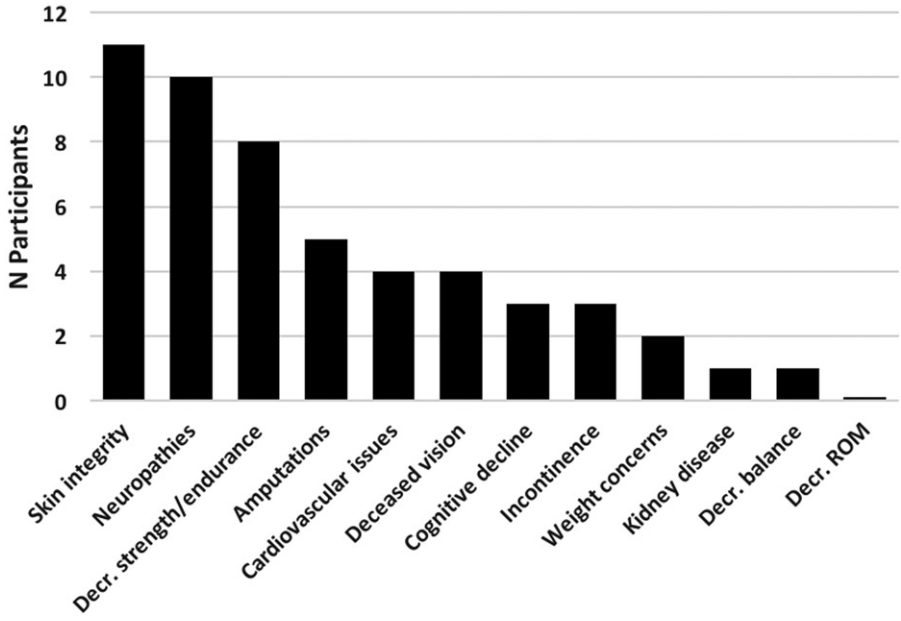

Figure 1. Conditions associated with diabetes and functional limitations spontaneously mentioned by participants when asked to name aspects of diabetes influencing their MWC adjustments.

done to provide participants with the opportunity to confirm and clarify the data [33]. Moreover, investigator triangulation was adopted through a review of each transcript by a second researcher, and by having two researchers independently coding the same transcript to establish an in-depth understanding of the data from two different standpoints. Finally, data saturation was considered to have been reached, as per Bowen [34], since the recruitment and interviewing process was terminated once the analyzes produced no new thematic data.

Results

In total, 13 participants were interviewed in this study. Among them were seven occupational therapists, three physical therapists, two wheelchair technicians and one physician. Seven participants were working in North America, one in South America, one in Africa, two in Australia and two in South Asia. Seven of them had experience working in a less-resourced setting, or with clients living in such a context. The amount of experience working in MWC delivery services ranged from 3 to 25 years (see Table 2 for participants' demographics). All participants mentioned having previous experience prescribing wheelchairs to individuals with diabetes.

According to the participants, people with diabetes requiring a MWC generally present with a variety of associated conditions, making them complex cases. Therefore, clinicians confirmed that while diabetes may be the underlying diagnosis, they considered the conditions associated with diabetes to be more important than the diagnosis itself. These conditions, their interaction and the resulting functional impact were seen as the main factors requiring appropriate MWC adjustments. Among the multiple conditions associated with diabetes and functional limitations, some were spontaneously mentioned by many participants during the initial part of the interview, as having an influence on their intervention, such as neuropathies and skin integrity. On the other hand, other associated conditions, such as limitations in range of motion (Figure 1), were mentioned by participants only when probed. These associated conditions became the main themes of this study, which were then subdivided according to the clinical purpose of the MWC adjustment (Table 3). The separate classification of themes for the MWC adjustments related to interventions in less-resourced settings was subdivided in terms of types of difficulties encountered (Table 4).

Table 3. Participants' suggestions of MWC features and adjustments according to various conditions associated with diabetes or functional limitations, with examples of specific interventions.

Purpose	Examples of MWC features
Impaired vision & neuropathies	
Proprioceptive feedback, perception & prehension	Quick-release axle activated by pull-out loop for easier grasp; Visual cues on brakes; Brake extensions or large brake handles; Anti-skid (e.g., silicone & plasticized) or textured handrim & brake handles
Neuropathic pain reduction	Elevating lower leg supports
Incident & pressure point prevention	People with impaired vision are more at risk for collisions and less likely to notice skin issues. *Refer to the Skin Integrity section for more suggestions.*
Skin integrity	
Sore prevention (cushions)	Interconnected air cells cushions in the presence/risk of pressure sores; Seat cushions with the most air flow in cases of non-autonomous pressure relief; Gel seat cushion used in presence of shearing forces; Fluid gel as an alternative to air cushions due to its properties of immersion
Sore prevention (other than cushion selection)	Lateral adductor supports to avoid pressure created by lower limbs resting against the foot support; Adjustment of foot support to minimize pressure; Padding of foot support for protection during weight-bearing transfers; Wide back support angle for greater pressure distribution; Deep seat for greater pressure distribution
Incident risk reduction	Brake handles that fold away under the seat and adjustment of the distance between handrim & wheels to avoid finger trapping; Elimination/padding of sharp edges (e.g., foot support anchors); Posterior foot support installation to prevent feet from sliding backwards; Posterior lower leg support to replace posterior foot support in presence of ankle sores
Contact area softening	Elimination of rough surfaces rubbing against the skin (e.g., hard Velcro®, stitches)
Incontinence & perspiration management	Use of water resistant, breathable & washable material for seat cushion covers (e.g., nylon & lycra); Addition of a washable absorbent incontinence sheet on top of a waterproof seat cushion cover
Amputations	
Contracture management	Adjustable stump support angle up to full knee extension, conforming to stump's shape & contracture
Stability improvement	Center of gravity shift compensation for above-knee amputations: backwards displacement of wheels' axle & lengthening of the wheelbase.
Facilitation of propulsion	One-hand drive MWC in case of hand/finger amputation
LE stabilization	Gutter-like designed stump support to stabilize residual limb
Residual & remaining limb protection	Breathable fabric to help wounds heal (e.g., neoprene is durable & low maintenance); Increased padding on stump supports; Cover material that minimizes abrasion (e.g., leatherette); *Refer to the Skin Integrity section for more suggestions.*
Obesity	
Comfort improvement	Back support angle widening in presence of a protruding abdomen for sliding prevention; Comfort over perfect posture (e.g., postural support devices may interfere with breathing capacity by compressing the rib cage)
Pressure point reduction	Dense seat cushion for weight support; Frequent seat cushion replacement due to reduced efficiency and lifetime
Mobility within the community	Absence of arm support/handrim to decrease the overall width of the MWC; MWC width reduction with flesh compression to increase handrim accessibility; Lighter MWC to limit the weight being propelled
MWC strength increase	Double-X frame for robustness, stability & durability; Steel frame and reinforced wheels for robustness
Peripheral vascular conditions (oedema)	
Pressure point reduction & skin protection	Coordination of seat & foot supports height to decrease pressure under seat bones; Elevating lower leg supports combined with MWC tilt; *Refer to the Skin integrity section for more suggestions.*
Facilitating propulsion	Seat depth adjustment to allow comfortable LE propulsion; *Refer to the Decreased motor performance section for more suggestions.*
Decreased motor performance	
Facilitation of propulsion	Appropriate arm support (e.g., high arm support may limit adequate propulsion); Back support angle close to 90° for optimal mechanical advantage on wheels; Low back support allowing to pull elbows behind, increasing leverage on the wheels; Inclined seat in case of forward sliding during LE propulsion; Handrim modifications (e.g., anti-skid coating, large diameter, oblique projections); Inward camber of the wheels to increase mechanical advantage when propelling; Thin tyres are lighter than wider tyres, limiting friction with the ground; Rear wheels: optimization of position and increased size; Light & rigid frames (long-lasting, minimal energy expenditure); Compact MWC design (better shoulder positioning and pelvis stabilization)
Transfers facilitation	Long & stable arm support; Increased seat height
Stability increase	Backward tilting of back support and seat to stabilize the client in the MWC; Stable seat cushion (e.g., gel or foam over air)
Cognitive decline	
Safety promotion	Automatic braking system; Visual cues on brakes as reminders
Feeling of calmness	Lowering seat & removing foot supports to allow feet to touch the ground
Skin protection	High performance seat cushions to compensate for limited autonomous transfers & pressure relief abilities

For complete information, including specific considerations in relation with the various suggestions, please see the full table in the Supplementary Material

Table 4. Participants' opinions on MWC features and adjustments that may be indicated for specific conditions related to diabetes, but contraindicated for other conditions.

Feature	Indications	Contraindications
Elevating lower leg supports	Neuropathic pain: pain reduction	Skin integrity: may increase pressure on ischial tuberosities
Wide back support angle	Skin integrity: sores prevention due to greater pressure distribution	Motor performance: impedes propulsion efficiency Skin integrity: increases sliding on seat
Deep seat	Skin integrity: sores prevention due to greater pressure distribution	Motor performance: makes transfers and propulsion more difficult
Water resistant, breathable & washable material for seat cushion covers	Incontinence	Skin integrity: skin maceration problems with impermeable cushions and covers.
Incontinence sheets	Incontinence	Skin integrity: may decrease the cushion's efficiency in terms of pressure distribution
Adjustable stump support angle up to full knee extension	LE amputation: prevention of contractures	Skin integrity: may increase pressure points
Backwards displacement of wheels' axle	LE amputation: increases stability of MWC	Motor performance: may impede propulsion efficiency
High density cushion	Obesity: better weight support	Skin integrity: negative impact on pressure distribution
Reduced MWC width	Obesity: increases MWC accessibility (doorways) and UE propulsion ability	Skin integrity: compressed skin at higher risk of pressure sores
Increased seat height	Motor performance: facilitates transfers	Motor performance: impedes propulsion efficiency Skin integrity: increases sliding on seat
Anterior pelvic support	Cognitive decline: helps prevent falls	Skin integrity: can prevent position changes, therefore impeding pressure relief
Decreased seat height	Cognitive decline: decreases anxiety by allowing feet to touch the ground	Motor performance: makes transfers more difficult

Conditions associated with diabetes and functional limitations

Impaired vision and neuropathies

People with impaired vision and sensation were considered at greater risk for collisions. Other intervention areas related to sensation included impaired perception and prehension, and neuropathic pain. For example, brake extensions were mentioned by participants as helpful to MWC users with reduced sensation; however, it was noted that these were less durable than standard brakes.

Skin integrity

Considerations attributed to skin integrity were: risks of sores, incidents during transfers and propulsion, and incontinence or perspiration-related issues. Many suggestions were made in regards to seat cushions. Medium to high performance pressure relief cushions and multiple-layer foam cushions were prescribed to prevent further skin breakdown. Indeed, according to participants, lower quality 2″ cushions can be quickly compressed, making them less efficient in the long run. In contrast, interconnected air cell cushions were preferred to prevent or manage pressure sores, but may be unstable for those with decreased balance. "Where I work, now, the cushion, as soon as there seems to be [...] a risk of sore on a diabetic patient, right away, the first choice will be a ROHO cushion, unless there is an instability problem". Finally, gel cushions were recommended when risks associated to shearing of the skin were present. Fluid gel cushions were also suggested as an alternative to air cushions for their adequate immersion of bony prominences and reduced need for maintenance.

Amputations

Participants made several suggestions on the protection and stabilization of the residual limb, on prevention and management of contractures, as well as on MWC adjustments to facilitate propulsion and to improve stability. For example, the change in the centre of gravity may be compensated by moving the rear wheels' axle towards the back, but may jeopardize comfortable upper extremity (UE) access to the wheels.

Obesity

Particular attention was paid to MWC strength, comfort, pressure point reduction, skin protection, as well as community mobility. According to participants, propulsion would be facilitated with a lightweight MWC, however, the durability of such a MWC under heavy loads was said to be a concern; some clinicians would prefer a double-X frame made of steel.

Peripheral vascular conditions – oedema

Suggestions for MWC adjustments were made in response to issues regarding lower extremity oedema and focused on pressure reduction, oedema reduction, skin protection and facilitation of propulsion. For example, to decrease oedema, elevated leg supports (or elevated leg rests) should be combined with a MWC tilt to raise the legs above the heart.

Decreased motor performance

Suggestions related to motor impairments such as strength, endurance, range of motion and balance, were aimed at facilitating transfers and MWC propulsion. Lighter MWC and rigid frames would be recommended as they are long-lasting and require less strength and energy expenditure than standard frames, allowing for an increased independence in propulsion. However, due to their higher cost, they are usually allocated to active users who propel themselves over longer distances. Therefore, clinicians faced difficulties when justifying their prescription for clients with diabetes presenting with decreased strength and endurance. As expressed by one participant:

> [...] it's difficult sometimes to justify a more lightweight chair that is seen as a high performance chair but if people have general [disability] and particularly fluctuating energy over the day in relation to their condition, that would be a really good reason to set the chair up very well, [...] it really upsets me when, particularly if someone is older, they just get plumped in what looks like a nursing home chair whereas you can really get people very mobile if you just try a little bit.

Cognitive impairment

In cases of cognitive decline, an emphasis was placed on promoting safety, on providing a sense of calm and stability by keeping

Table 5. Participants' suggestions of MWC features and adjustments for clients with diabetes living in a less-resourced setting, with examples of specific interventions.

Issues	MWC features or other interventions
Limited accessibility	
Architectural barriers	School or community support programs to find solutions adapted to the context
Environmental barriers	Airless tyres to avoid puncture; Large wheels for rough terrains
Limited access to healthcare	Thorough & frequent MWC inspections; Self-management education/Community-Based Rehabilitation programs & follow-ups
Limited access to adapted equipment	Frequent follow-ups recommended to address complications, especially if MWC could not be fully adjusted to the person's needs; Homemade equipment: addition of cardboard to low quality foam seat cushions; addition of wood inserts to adjust arm supports' heights; stump support made from lower leg support; using a stool instead of leg support to elevate legs
Limited possibilities for maintenance & manipulation	
Sanitation (incontinence or humid climate)	Waterproof seat cushion should be used although some types may increase risks of maceration (permeable/foam seat cushions cannot be washed nor reused); Provision of 2 seat cushion covers to allow for alternate cleaning & usage
Adjustments required by caregiver or client	Flat cushion (can be placed in any direction); Foam or gel seat cushion necessitating less adjustments than air cushions; Preference for individual over interconnected air cells (a single cell rupture has a moderate effect on the seat cushion)
Robustness, reliability & durability	Adjustable arm support to allow for changes over time; Fixed axles (more robust than quick release axles); Avoiding foot supports & lower leg support when feet propulsion is possible due to high maintenance needs; Robust frame and wheels for durability; Robust seat sling insert to avoid sling stretching & buttocks compression; Stainless steel spokes to avoid rusting

For complete information, including specific considerations in relation to the various suggestions, please see the full table in the Supplementary Material.

the feet on the ground, and on protecting the skin through preventive MWC adjustments.

Indications and contraindication

Many participants also remarked that specific MWC adjustments may be beneficial for some conditions associated with diabetes, but may be simultaneously contraindicated for other conditions present in the same individual, as shown in Table 4. For example, a wide back support and a deep seat are important to increase pressure distribution and help to maintain skin integrity. However, this adjustment also makes transfers and propulsion more difficult, which is of concern if the same client is overweight or has decreased motor performance. In clients with amputations, participants noted the importance of including an adjustable stump support, allowing full knee extension to prevent contractures. However, this can increase pressure on the skin when the knee is in full extension, as well as the risk of injury from collisions for individuals who also have sensory or visual impairments. Thus, many clinicians insisted on the need to understand the pros and cons of specific MWC adjustments in the case of clients with diabetes who may have complex symptoms.

Considerations for less-resourced settings

The secondary objective of this research was related to the applicability of MWC adjustments to less-resourced settings (Table 5). We analyzed the answers of the seven participants with experience in such settings. In this context, there was a prevalence of accessibility issues, such as environmental barriers, where propulsion is difficult due to irregular terrain. Features such as airless tyres (preventing puncture incidents) and large wheels could help to address this matter. According to participants, opportunities for maintenance of MWCs are restricted due to limited access to trained technicians. Therefore, robust, reliable and durable equipment with few adjustable components should be favoured. For example, a flat seat cushion, which can be placed in any direction, is often preferred. "There's less risk for the flat cushion to be placed on the wrong side. The profiled cushion, if put upside down, instead of keeping the person well-seated on the wheelchair, creates a sliding motion, which is not ideal".

Restricted access to equipment, limiting the ability to properly fit the MWC to the client's needs, creates a higher need for frequent follow-ups. Moreover, limited access to healthcare renders self-management and community-based rehabilitation programs are very important for the prevention of injuries and complications related to diabetes.

Discussion

Through expert opinions, the aim of this study was to explore the clinical reasoning of expert clinicians regarding MWC adjustments for people with diabetes, and to explore the application of these findings in less-resourced regions. The spontaneous concerns most frequently mentioned by participants for people with diabetes requiring a MWC were skin integrity and neuropathies. Most clinicians mentioned the importance of cushions for skin integrity, showing a preference for interconnected air-cells. Furthermore, the difficulty in justifying specialized equipment and the frequent compromises required when adjusting MWCs, considering different diabetes-associated conditions, were commonly discussed among the participants.

Conditions associated with diabetes and functional limitations considered by clinicians when adjusting MWC

At the beginning of the interview, participants were asked an open-ended question about which diabetes-related conditions they would consider when making MWC adjustments. Some discrepancies were observed between conditions spontaneously mentioned by participants, and the actual prevalence of these associated conditions in the diabetic population. The greatest concerns expressed by clinicians were related to neuropathies, which is consistent with its prevalence in 60–70% of the diabetic

population [4]. The consequences of neuropathies on skin integrity and their direct impact on MWC adjustments (seat cushions, seating, etc.) were of great concern to the participants.

However, with arthritis affecting 52% of people with diabetes in the United States [35], it is surprising that limitations in range of motion caused by this condition were not spontaneously mentioned as impacting MWC propulsion, and how this may be improved through appropriate adjustments. Similarly, diabetes was found to be the leading cause for new cases of blindness and for kidney failure among adults living in the United States, affecting around 4.2 million and 228 million people, respectively [36]; but impaired vision and kidney failure were, in general, not spontaneously mentioned by participants as factors to consider when adjusting a MWC. One explanation may be that people with diabetes and mobility needs present with a different profile than the general diabetic population. Indeed, shorter life expectancy in certain parts of the world may create a lower incidence of complications related to diabetes. This may explain why some clinicians do not deal with complications such as arthritis, low vision or kidney failure in their respective practices [37]. Therefore, it may be beneficial to identify specific characteristics of people with diabetes and MWC mobility needs to expand on future clinical guidelines for MWC adjustments specific to this population.

Evidence on the efficiency of air seat cushions

Results from this present study revealed a preference for interconnected air-cell seat cushions (e.g., ROHO®), especially in managing pressure sores. The influence of studies funded by the ROHO® company itself was discussed, as well as its proactivity in providing data to institutions, which may positively influence the choice for this brand over other options. Up to now, some evidence suggests ROHO's superior effectiveness in distributing pressure at the buttocks [18,38]. However, consistency in the cushion's model testing and comparison of various existing types of cushions are lacking. Disadvantages of air cushions were notably mentioned by participants, such as their high cost, their requirement for regular maintenance and their instability with respect to sitting balance, in agreement with a study by Stockton et al. [21]. These researchers [21] have highlighted the divergent personal opinions on various cushions' efficiency in particular circumstances, which could be a consequence of the lack of scientific evidence on this matter. Thus, to make an informed choice, it is important to have a thorough understanding of all available seat cushions' properties.

Lightweight and ultra-lightweight MWC

The weight category of a MWC is usually selected based on the person's functional abilities rather than on the diagnosis [39,40]. Indeed, some participants in this study mentioned that lighter MWC are generally prescribed to active users who propel over long distances rather than elderly, frail or sedentary users, which is in line with reports from literature on that matter [16,41]. Unfortunately, MWC users with diabetes are more likely to correspond to the latter category, and this way of prescribing may contribute to further functional limitations. Various authors [16,42] have highlighted the importance of minimizing the energy cost of propulsion in frail or elderly users through proper fitting and MWC weight reduction. This would help to maintain participation, limit shoulder injuries [17] and increase active mobility and lifestyle [43, 44], thus contributing to improvements in body weight and general health management [45], limiting the impact of diabetes.

Compromises and challenges in a less-resourced setting

Choosing a robust, reliable and high performance MWC is particularly important when prescribing MWC in less-resourced settings. However, despite continuing efforts made by some organizations to provide users with appropriate MWC, lack of funding in these settings often result in seating specialists prescribing cheaper wheelchairs, trading the appropriateness of the MWC for the ability to provide a greater number of MWC [46]. Nonetheless, actual ISO standards for MWC [47] may not be appropriate for rural areas [48]; therefore, the WHO has recommended the elaboration of national standards adapted to local specific needs [48], and has created guidelines and training packages for MWC provision in various contexts [15,16,48].

Recommendations made by participants in our study go beyond the aspects of MWC fitting in the WHO documents. Considerations for reduced sensation are only mentioned as an issue in individuals with spinal cord injury, stroke or spina bifida, but not with diabetes. Pressure sore risks are only addressed with regards to slower healing processes in the case of diabetic amputations and increased pressure points in the presence of obesity. Propulsion, MWC strength, comfort and community mobility issues with obesity are not mentioned. Other considerations brought up by this study's participants, such as impaired vision, LE oedema and cognitive impairments, are not addressed in the WHO documents.

These omissions could have tremendous impacts on people with complications related to diabetes, specifically in less-resourced countries, where the prevalence of diabetes is high [49]. Indeed, low and middle income countries account for 77% of all worldwide cases of diabetes. Diabetic foot disease is considered to be a leading cause of hospitalization and amputations in diabetic patients from sub-Saharan Africa and remains very common in other regions, such as India [9].

Recommendations made by this study's participants in terms MWC provision and fitting require additional initial investments in a global context where resources are often sparse. However, the investment in low-cost equipment could be negated by the cost of repairs, replacements and complications requiring health care services [9,46]. Furthermore, this forces clinicians to make compromises between reliability, efficiency and durability of equipment when considering complications of diabetes. Thus, there is a need for increased availability of affordable and adjustable MWC and MWC equipment adapted to the diabetes' profile and encompassing properties related to both durability and reliability, especially in less-resourced settings. Stakeholders also need to advocate for investments in durable and adequate equipment for better long-term cost-effectiveness.

Study limitations

Due to the explorative nature of this study, many factors limit the authors' abilities to generalize the information gathered, which would have to be achieved in a subsequent research. The relatively small sample size constitutes a first factor limiting generalization, however it is considered to be adequate for most interpretive studies and was sufficient to reach data saturation [50]. Moreover, a very diverse group of experts was selected in order to provide this study with a wide variety of experiences and opinion; their statements have to be approved by a broader group of experts before they can be considered as guidelines. The small number of participants from some regions of the world will also limit the generalization of the data collected within specific regions. Another limitation was that diabetes generally co-exists

with other co-morbidities, and might not have been the primary reason for referral for an evaluation and prescription of a MWC, potentially influencing the ability to collect data directly related to diabetes and MWC adjustments.

Conclusions

Participants in this study shared their clinical reasoning and agreed on the need of specific MWC adjustments to accommodate various issues caused by diabetes-related conditions. In particular, participants confirmed that the conditions associated with diabetes, such as neuropathy, obesity and amputations, are the determining factors dictating appropriate MWC adjustments, rather than the diagnosis of diabetes itself. The challenge is in simultaneously managing multiple conditions associated with diabetes, often present in the same individual. Indeed, some MWC adjustments may be beneficial for a particular condition, but contraindicated for others. People with diabetes and mobility limitations may present with a different profile than those with diabetes and no mobility limitations; this profile, modulated by regional and systemic contexts, must be determined more precisely. In terms of equipment, air cushions were considered by our participants as a key item for people with diabetes, as it was considered as most efficient in the prevention and management of pressure sores. Moreover, well-adjusted lighter MWC should be considered in order to improve the mobility of populations with diabetes and to possibly reduce long-term healthcare costs. Specifically, in less-resourced settings, there is a need to increase the availability and affordability of MWCs and equipment that is adapted to the diabetic population, without compromising their durability and reliability. These considerations, along with the numerous MWC adjustments suggested by our experts, may help to define future clinical guidelines in a global perspective.

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References

[1] Cho NH, Whiting D, Guariguata L, et al. IDF diabetes atlas. 6th ed. Brussels: International Diabetes Federation; 2014.

[2] Wild S, Roglic G, Green A, et al. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diabetes Care. 2004;27:1047–1053.

[3] Hossain P, Kawar B, El Nahas M. Obesity and diabetes in the developing world – a growing challenge. N Engl J Med. 2007;356:213–215.

[4] Centers for Disease Control and Prevention. National diabetes fact sheet: national estimates and general information on diabetes and prediabetes in the United States. Atlanta: US Department of Health and Human Services, Centers for Disease Control and Prevention; 2011.

[5] Kalyani RR, Saudek CD, Brancati FL, et al. Association of diabetes, comorbidities, and A1C with functional disability in older adults results from the National Health and Nutrition Examination Survey (NHANES), 1999–2006. Diabetes Care. 2010;33:1055–1060.

[6] Moxey PW, Gogalniceanu P, Hinchliffe RJ, et al. Lower extremity amputations – a review of global variability in incidence. Diabetic Med. 2011;28:1144–1153.

[7] Yaffe K, Falvey C, Hamilton N, et al. Diabetes, glucose control, and 9-year cognitive decline among older adults without dementia. Arch Neurol. 2012;69:1170–1175.

[8] Lifford KL, Curhan GC, Hu FB, et al. Type 2 diabetes mellitus and risk of developing urinary incontinence. J Am Geriatr Soc. 2005;53:1851–1857.

[9] Boulton AJ, Vileikyte L, Ragnarson-Tennvall G, et al. The global burden of diabetic foot disease. Lancet. 2005;366:1719–1724.

[10] Brienza D, Kelsey S, Karg P, et al. A randomized clinical trial on preventing pressure ulcers with wheelchair seat cushions. J Am Geriatr Soc. 2010;58:2308–2314.

[11] Nigatu T. Epidemiology, complications and management of diabetes in Ethiopia: a systematic review. J Diabetes. 2012;4:174–180.

[12] Hicks CW, Selvarajah S, Mathioudakis N, et al. Trends and determinants of costs associated with the inpatient care of diabetic foot ulcers. J Vasc Surg. 2014;60:1247–1254.

[13] Di Marco A, Russell M, Masters M. Standards for wheelchair prescription. Aust Occ Ther J. 2003;50:30–39.

[14] Lukersmith S, Radbron L, Hopman K. Development of clinical guidelines for the prescription of a seated wheelchair or mobility scooter for people with traumatic brain injury or spinal cord injury. Aust Occup Ther J. 2013;60:378–386.

[15] Frost S, Mines K, Noon J, et al. Wheelchair service training package – reference manual for participants – basic level. Geneva: World Health Organization; 2012.

[16] Frost S, Mines K, Noon J, et al. Wheelchair service training package – reference manual for participants – intermediate level. Geneva: World Health Organization; 2013.

[17] Cooper RA, Koontz AM, Ding D, et al. Manual wheeled mobility – current and future developments from the human engineering research laboratories. Disabil Rehabil. 2010;32:2210–2221.

[18] Gil-Agudo A, De la Pena-Gonzalez A, Del Ama-Espinosa A, et al. Comparative study of pressure distribution at the user–cushion interface with different cushions in a population with spinal cord injury. Clin Biomech. 2009;24:558–563.

[19] Guimaraes E, Mann WC. Evaluation of pressure and durability of a low-cost wheelchair cushion designed for developing countries. Int J Rehabil Res. 2003;26:141–143.

[20] Okunribido OO. Patient safety during assistant propelled wheelchair transfers: the effect of the seat cushion on risk of falling. Assist Technol. 2013;25:1–8.

[21] Stockton L, Gebhardt KS, Clark M. Seating and pressure ulcers: clinical practice guideline. J Tissue Viability. 2009; 18:98–108.
[22] Herman JH, Lange ML. Seating and positioning to manage spasticity after brain injury. NeuroRehabilitation 1999;12:105–117.
[23] Regan MA, Teasell RW, Wolfe DL, et al. A systematic review of therapeutic interventions for pressure ulcers after spinal cord injury. Arch Phys Med Rehabil. 2009;90:213–231.
[24] Rispin K, Wee J. Comparison between performances of three types of manual wheelchairs often distributed in low-resource settings. Disabil Rehabil Assist Technol. 2015; 10:316–322.
[25] Thorne S, Con A, McGuinness L, et al. Health care communication issues in multiple sclerosis: an interpretive description. Qual Health Res. 2004;14:5–22.
[26] Mortenson WB, Miller WC. The wheelchair procurement process: perspectives of clients and prescribers. Can J Occup Ther. 2008;75:167–175.
[27] Torkia C, Reid D, Korner-Bitensky N, et al. Power wheelchair driving challenges in the community: a users' perspective. Disabil Rehabil Assist Technol. 2015;10:211–215.
[28] Routhier F, Vincent C, Desrosiers J, et al. Development of an obstacle course assessment of wheelchair user performance (OCAWUP): a content validity study. Technol Disabil. 2004;16:19–31.
[29] Cohen LJ, Fitzgerald SG, Lane S, et al. Development of the seating and mobility script concordance test for spinal cord injury: obtaining content validity evidence. Assist Technol. 2005;17:122–132.
[30] Dye JF, Schatz IM, Rosenberg BA, et al. Constant comparison method: a kaleidoscope of data. Qual Rep. 2000;4:1–10.
[31] Seale C, editor. Validity, reliability and the quality of research. In: Researching society and culture. 2nd ed. London: Sage; 2004. p. 71–83.
[32] Sandelowski M. Reembodying qualitative inquiry. Qual Health Res. 2002;12:104–115.
[33] Tuckett AG. Part II. Rigour in qualitative research: complexities and solutions. Nurse Res. 2005;13:29–42.
[34] Bowen GA. Naturalistic inquiry and the saturation concept: a research note. Qual Res. 2008;8:137–152.
[35] Centers for Disease Control and Prevention. Arthritis as a potential barrier to physical activity among adults with diabetes – United States, 2005 and 2007. Morbidity and mortality weekly report. 2008. p. 486.
[36] Centers for Disease Controland Prevention. National diabetes statistics report: estimates of diabetes and its burden in the United States. 2014.
[37] World Health Organization [Internet]. Fact Sheet: the top ten causes of death. 2007. Available from: http://www.who.int/mediacentre/factsheets/fs310.pdf.
[38] Levy A, Kopplin K, Gefen A. An air-cell-based cushion for pressure ulcer protection remarkably reduces tissue stresses in the seated buttocks with respect to foams: finite element studies. J Tissue Viability. 2014;23:13–23.
[39] Medola FO, Elui VMC, da Silva Santana C, et al. Aspects of manual wheelchair configuration affecting mobility: a review. J Phys Ther Sci. 2014;26:313.
[40] Sprigle S, De l'aune W. Factors contributing to extended activity times during the provision of wheeled mobility devices. Disabil Rehabil Assist Technol. 2013;8:225–231.
[41] Bruce DG, Davis WA, Davis TM. Longitudinal predictors of reduced mobility and physical disability in patients with type 2 diabetes the Fremantle Diabetes Study. Diabetes Care. 2005;28:2441–2447.
[42] Requejo PS, Furumasu J, Mulroy SJ. Evidence-based strategies for preserving mobility for elderly and aging manual wheelchair users. Top Geriatr Rehabil. 2015;31:26.
[43] Giesbrecht EM, Miller WC, Woodgate RL. Navigating uncharted territory: a qualitative study of the experience of transitioning to wheelchair use among older adults and their care providers. BMC Geriatr. 2015;15.
[44] Marchiori C, Bensmail D. Manual wheelchair satisfaction among long-term users and caregivers: a French study. J Rehabil Res Dev. 2015;52:181
[45] Sigal RJ, Armstrong MJ, Colby P, et al. Physical activity and diabetes. Can J Diabetes. 2013;37:S40–SS4.
[46] Visagie S, Duffield S, Unger M. Exploring the impact of wheelchair design on user function in a rural South African setting. AJOD. 2015;4:8.
[47] ISO/TC 173/SC 1. ISO 7176-1 Wheelchairs. Pretoria: International Organization for Standardization; 2014. p. 28.
[48] Armstrong W, Borg J, Krisack M, et al. Guidelines on the provision of manual wheelchairs in less-resourced settings. Geneva: World Health Organization; 2008.
[49] World Health Organization. Global report on diabetes. Geneva: World Health Organiszation; 2016.
[50] Atran S, Medin DL, Ross NO. The cultural mind: environmental decision making and cultural modeling within and across populations. Psychol Rev. 2005;112:744