ON-BOARD LIVED EXPERIENCE OF MANUAL WHEELCHAIR USERS: AIRCRAFT SEAT SATISFACTION LEVEL AND POTENTIAL SOLUTIONS TO IMPROVE COMFORT AND ACCESSIBILITY

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ABSTRACT

This study investigates the satisfaction level of manual wheelchair users with regard to aircraft seat. It also examines their perceptions about potential solutions that could be proposed to improve accessibility, comfort and seated stability. Data were gathered from a sample of 31 manual wheelchair users. Participants were asked to fill a questionnaire that was composed of three key domains: (1) flight characteristics, (2) satisfaction related to accessibility, comfort and seated stability on aircraft seat and (3) perception of aircraft seat solutions. On section 1, results show that the majority of participants used economy class. In addition, among three seat locations within the aircraft, the majority of manual wheelchair users mentioned that the window seat was their favorite place. However, even if the window seat is the favorite location, participants estimated that transferring to this seat is challenging. On section 2, transfer on aircraft seat is problematic. Participants express the need to have a place in the first seat row in order to facilitate their accessibility and comfort. Consumers will have more legroom and could stretch their leg to avoid pressure sores. Also, seated stability is another parameter to take in to account for manual wheelchair users. Indeed, certain participants have a lack of stability due to an alteration of their abdominal and lumbar muscle. Their stability is being tested during several step of the flight as takeoff, landing and turbulence. On section 3, participants would appreciate additional adaptations on armrest and seat that would improve their comfort, accessibility or even the seated stability.

Keywords: Ergonomic, aircraft seat, adaptation, wheelchair user perceptions

Introduction

According to a report by the World Health Organization (2011), more than a billion people are estimated to live with some form of disability, or about 15% of the world's population. Also, it is generally estimated that one out of six Europeans suffers from a disability (European commission, 2011). People with disability, even if they are not wealthy, have adequate resources to travel several times per year, especially for the purpose of vacations, family visits, and medical care (Burnett & Baker, 2001).
The Open Doors Organization (2005) reported that 31% of adults with disabilities traveled by air. Disabled travelers approximately take 2 flights every two years and would take 2 more flights per year if their needs as a disabled person were considered by the airlines. Among adults with disabilities who have traveled by air, 72% said they encountered major obstacles with airlines. Physical obstacles and cramped seating areas were the most reported complaints (Open Doors Organization, 2015).

Aware of difficulties encountered by disabled person, the tourism literature is increasingly turning its attention to tourist with disabilities (Chang & Chen, 2012a, 2012b; Grant, 2013; Morgado et al., 2016; Davies & Christie, 2017, 2018). Some studies identified problems and difficulties encountered by all profile of disabled people, from people with sensory disabilities to ones with physical impairment.

Europe is the home of 37 million people with physical disabilities (Blichfeldt & Nicolaisen, 2011). And ageing European population will continuously grow the number of passengers who need special assistance (European commission, 2011). Given this observation, attention is paid to literature focusing on people with physical disabilities. For studies focusing on people with physical impairment, some concentrate on the details of aircraft design while others refer only to general issues of an airplane journey. Concerning the aircraft design, the limited physical dimensions create difficulties for accessibility especially in aircraft seats (Morgado et al., 2016; Aquino et al., 2014). For some passengers the seats on the aircraft are described as unsuitable (Davies & Christie, 2018). The distance between two seats could be very small which creates displacement equipment deficiencies, for people with physical impairments as wheelchair users. For example, the distance between the front of the seat and the backrest of the front seat (pitch) smaller than 28 inches makes the space between seats very small. Another example of equipment deficiencies, bathrooms inside the aircraft are often inaccessible for wheelchair users (Davies & Christie, 2017; Law, 2012) and in some cases regulation does not allow people that cannot move by themselves to travel alone (United Spinal Association, 2012). Then the accessibility within aircraft for wheelchair users is very complicated.

In their study, Poria et al. (2010) analyzed on-board experience for different groups of disabled people, especially wheelchair users. They find that the difficulties of these consumers originate mainly from the physical environment within the plane. As standard wheelchairs are too wide for airplane aisles, manual wheelchair users transfer on a boarding chair to be taken to their allocated aircraft seat. The transfer from the boarding chair to the aircraft seat, and vice versa, often causes pain related to bruises and sores (Davies & Christie, 2017). Participants explained that they could be physically hurt if the seat armrest cannot be completely lowered. In fact, various manual wheelchair users have reported an increased risk of skin integrity alteration during the transfer that could alter their health-related quality of life. Poria et al. (2010) emphasized the difficulties on the accessibility that correspond to the transfer on the seat for manual wheelchair users. Also studies previously conducted showed the difficulties of wheelchair passengers in regard to seat and equipement within the aircraft. However, they did not focus on what participants would prefer to improve their comfort, accessibility or seated stability during the flight. In addition, the previous studies regarding manual wheelchair users did not mention some modifications that could be proposed to improve access and comfort in aircraft seats or even stability for these users during the flight.

The main objectives of this study were two-fold: (1) to quantify the satisfaction level of manual wheelchair users with regard to aircraft seats and (2) to examine their perceptions about potential solutions that could be proposed to improve comfort, accessibility and seated stability.

Methods

I. PARTICIPANTS

The entire cohort of manual wheelchair users with spinal cord injury (N=31, sex 8 F/23 M, age=42±22 years, height= 151 ± 49cm, weight=114±66, body mass index= 50.75±35.75) were invited to anonymously complete a web-based electronic multifaceted questionnaire on Eval&GO© website. The Research Ethics Committee of the Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal approved the present study (CRIR-1083-0515).

II. QUESTIONNAIRE

The questionnaire encompassed a total of 31 statements that were organized around three key domains: (1) flight characteristics, (2) satisfaction related to accessibility, stability and comfort of aircraft seat and (3) perception of aircraft seat solutions. The questions were derived based on the survey of Chang & Chen (2011), literature reviews (Chang & Chen, 2012a, 2012b; Davies & Christie, 2017, Morgado et al., 2016), interviews with disabled passengers (Spartacus et al., 2018), and airport on-site visits. The survey was revised after testing on a simulated field (Spartacus et al., 2018).

On the section 1, participants were asked how many times they took the plane, which type of flight they used: short-haul (0-3 hours flight), medium-haul (3-6 hours flight), long-haul (over 6 hours flight) and which class of flight they traveled: economy class, premium economy class, business class, first class. The respondents were also required to indicate what aircraft seat location they used and preferred. Three choices were proposed: aisle seat, central seat, window seat. If participants didn't transfer on one of the seat type they can tick the box "Don't know". Then, respondents were required to indicate how they felt about the level of difficulty on each seat access (ingress and egress) using a visual analog scale (VAS) (Spartacus et al., 2018) ranging from "0=no difficulties" to "100 = action became impossible".

Section 2 focused on accessibility and seated stability in aircraft seat. Regarding the accessibility, participants were asked if they found difficult the transfer to the aircraft seat and also if their displacements in the plane was difficult. If participant found a difficulty on seat ingress or egress, they were asked about the level of difficulty with a range scale (Chan & Chen, 2011) from "1=few difficulties" to "5=action became impossible". Also participants gave their opinion on what could be changed. Regarding seated stability, participants were asked to evaluate their stability during four different parts of the flight: takeoff, landing, turbulence and during the flight. As previous, if participant found a difficulty during these four different parts they were asked about the level of difficulty with a range scale (Chan & Chen, 2011) from "1=few difficulties" to "5=action became impossible".

Section 3 dealt with some adaptations on the aircraft seat that could be proposed to manual wheelchair consumers. A preliminary study was conducted to determine what kind of modifications would be beneficial for manual wheelchair users to improve their accessibility (Spartacus et al., 2018). An aircraft platform previously built (Molenaar et al., 2015) was used to conduct experimentations. 4 manual wheelchair users were asked to transfer from the boarding chair to the aisle seat of the aircraft. After each transfer their perceptions and their opinion on what could be change were retrieved.
Small participants didn't touch the floor with their feet when they are seated in the aircraft seat. Also during the experiments, we noticed that the seat surface and the boarding chair seat surface were not at the same height. In order to address these problems we have the idea to propose a height adjustable seat. Also, some participants are less strong than the other. For them grabbing the armrest is complicated because it is far from their hand. In addition, the height of the armrest sometime does not fit with the size of participants. Thus, regarding the armrests we thought about armrest width and height adjustable to fit the requirements of travelers. In addition, for participants that have difficulties with the armrest we proposed a transfer handle that is proposed in buses.

Moreover, we realized that some participants used their pressure sore cushion because aircraft seat is not enough soft for them. This observation helps us to propose a seat with air cushion. Finally, thighs of tall participants were not in contact with the aircraft seat which lead to their knee being swung outward. In order to address this problem, we proposed a reclining seat.

Overall, seven adaptations were proposed: transfer handle as they exist in buses, footrest, height adjustable armrest on aircraft seat, armrest movable on aircraft seat during installation, height adjustable seat, reclining seat and seat with air cushion. Fig. 1 shows the adaptations proposed on the armrest and the transfer handle. Figure 2 shows the adaptation proposed on seat. Participants were asked if they will be interested by using the adaptations proposed. In the questionnaire, we didn't specify if each adaptation were especially made to improve transfer, comfort or even their stability during the flight. Thus, participants would answer to the question regarding these three parameters depending on their own choice.

Figure 1: Example proposed regarding the armrest and transfer handle. Adaptation on the armrest. (A) Armrest movable during installation (B) Height adjustable armrest (C) Transfer handle.

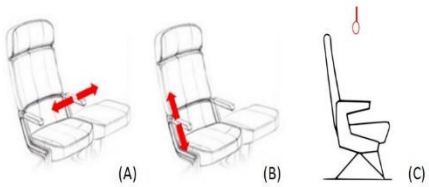
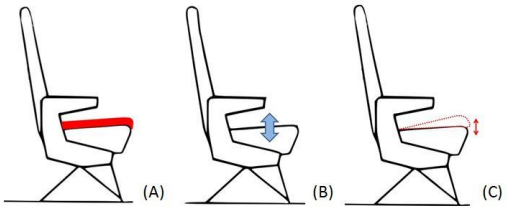


Figure 2: Example proposed regarding the aircraft seat. Adaptation on the aircraft seat. (A) Height adjustable seat (B) Reclining seat (C) Sea with air cushion



Results

I. FLIGHT CHARACTERISTICS

Questionnaire reviewed how many times consumers took the plane. 10 participants traveled ones or twice, 9 participants traveled between twice and ten times and 8 participants traveled more than ten times. Participants also used different types of flight: short-haul: 19%, medium-haul: 55%, long-haul: 26% and different class of flight with most of them using the economy class (economy class: 70%, premium economy class: 15%, business class: 9%, first class: 6%).

II. LOCATION IN AIRCRAFT SEAT

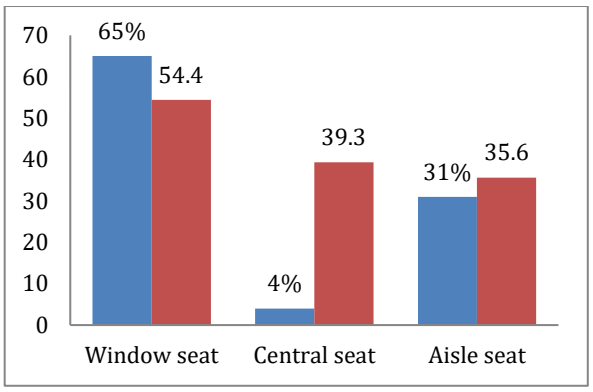
Among these different types of flight, participants used various seat locations. Table 1 gives the proportion of participants and associated number of participants that used the three different aircraft seat locations. The location mostly used were the window seat (48,4%), then the aisle seat (35,5%) and finally the central seat (16,1%) (Table 1). Figure 3 represents the favorite location in percentage and the level of difficulty to access on each seat. Results show that 65% of manual wheelchair users mentioned that

the window seat was their favorite place (Fig. 3). Then, for 31% of participants the aisle seat is preferred and for only 4% the central seat is the privileged location (Fig. 3). However, even if the window seat is the favorite location, participants estimated that transferring to this seat is challenging. The mean level of difficulties, expressed using the VAS, is equal to 54,4 and corresponds to a medium level of difficulty (Fig. 3). However, this level is important regarding to the resilience of people with disability (Dunn et al., 2012; Runswick-Cole & Goodley, 2013; Brazeau & Davis, 2018). Participants mentioned that the easier transfer was found to access on the aisle seat with a mean level of difficulty equal to 35,6 (Fig. 3).

Table 1: Proportion of subject using different location of the aircraft seat

	Proportion of participants	Number of participants
Aisle seat	35,5%	11
Central seat	16,1%	5
Window seat	48,4%	15

Figure 3: Percentage of participants regarding the favorite seat location (blue bars) and the mean level value of difficulty to move to the seat (red bars).



Participants said that they rather be on window seat even if the transfer is difficult because they are not disturbed by the displacement of the other passengers. Also, in order to be in their favorite place, participants said that they used the restroom before embarking. Thus, they did not go to the restroom during the flight to avoid disturbing other passengers.

III. AIRCRAFT SEAT SATISFACTION

a. Aircraft Seat Accessibility

Table 2 shows the percentage of participants having difficulties with aircraft seat access and the mobility inside the aircraft and the associated number of participants. Then for each category the level of difficulty from 1 to 5 is expressed as a percentage.

Table 2: Participants having difficulties and level of difficulties in relation to the accessibility within the aircraft

	Percentage of participants having difficulties	**Number of participants having difficulties**	**Level of difficulties**				
			1	**2**	**3**	**4**	**5**
Aircraft seat ingress	55%	17			60%	33%	7%
Aircraft seat egress	58%	18	6%	6%	38%	44%	6%
Mobility in the plane	35,5%	11			40%	10%	50%

Concerning the aircraft seat access (ingress/egress), more than 50% of participants had difficulties with aircraft seat access (table 2). Among 18 participants who experienced difficulties, 14 participants expressed their difficulties. For 6/14 participants the armrests were not removable. For 3/14, on-board personnel or their attendant had to carry them on their seat. 2/14 participants found a lack of room for the transfer. 1/14 participant hadn't enough support for the transfer. And 2/14 found that space between the aircraft seat and the boarding chair was too large.

In addition seat access is more difficult than the mobility inside the aircraft (table 2). Among 11 participants who experienced difficulties, 6 participants expressed their difficulties about the mobility inside the plane, 6 participants gave their feed back. 2/6 participants did not beneficiate of a boarding chair during the flight. 2/6 participants found the aisle too tight. 2/6 participants had difficulties with the boarding chair.

Furthermore, the level of difficulty assessed by participants concerning the seat access or mobility in the plane is important. Even for the seat egress, the level of difficulties is high. 88% of participants evaluated the level of difficulty between level 3 and 5 (table 2).

The inherent difficulties of manual wheelchair users on access to the aircraft seat are: the lack of room for legs, the limited availability of support points to move by themselves, the difference between seat surface and firmness, the elevated height of the boarding chair with respect to the aircraft seat and cabin crew who does not know the transfer technique.
In addition, participants gave their opinion on what could be changed. They express the need to have a place in the first row of cabin seat to facilitate the transfer and to have more room for legs. Participants reported that they cannot walk and have to stretch their legs to avoid pressure sores.

b. Aircraft Seat Stability

Seated stability is another parameter to take in to account for wheelchair users. Indeed for certain degree of spinal cord lesion participants have not their abdominal and lumbar muscle anymore. Then their stability is compromised. Turbulence and landing issues were identified as a problem amongst the more disabled participants because of balance issues (Davies & Christie, 2017). Table 3 enumerates the percentage of participants having difficulties with the seated stability during four perturbation of the flight from takeoff to turbulence. The number of participants having difficulties is associated to the percentage. In addition, the level of difficulty related to each category is mentioned.

In our study, participants feel more difficult to stay stable in their seat during turbulence than takeoff and landing with a p-values=0.01. The difficulty experienced by participants during takeoff was that they have to hold on with their hands to the backrest of the front seat or to the armrest. During turbulence participants had difficulties to keep the balance. In that case they were unstable and feel uncomfortable in their seat. For landing some participants were thrown forward during brake of the aircraft and had to hold back with the armrests.

Concerning the aircraft seat stability, less than 15% of participants found difficult to keep their stability during the flight. Percentage of participants having difficulties with seated stability is low. Furthermore, the percentage of participants having difficulties on the stability is less important than the percentage of participants having difficulties on transfer. However these difficulties have to take in to account because the level of difficulty for most of the stability items is from level 3 to 4 (table 3). This level is important regarding to the resilience of people with disability (Dunn et al., 2012; Runswick-Cole & Goodley, 2013; Brazeau & Davis, 2018).

Table 3: Participants having difficulties and level of difficulties in relation to the stability during the flight

	Percentage of participants having difficulties	**Number of participants having difficulties**	**Level of difficulties**				
			1	**2**	**3**	**4**	**5**
Seated stability during takeoff	6,5%	2			100%		
Seated stability during the flight	13%	4			67%	33%	
Seated stability during turbulence	10%	3			100%		
Seated stability during landing	10%	3	34%	33%	33%		

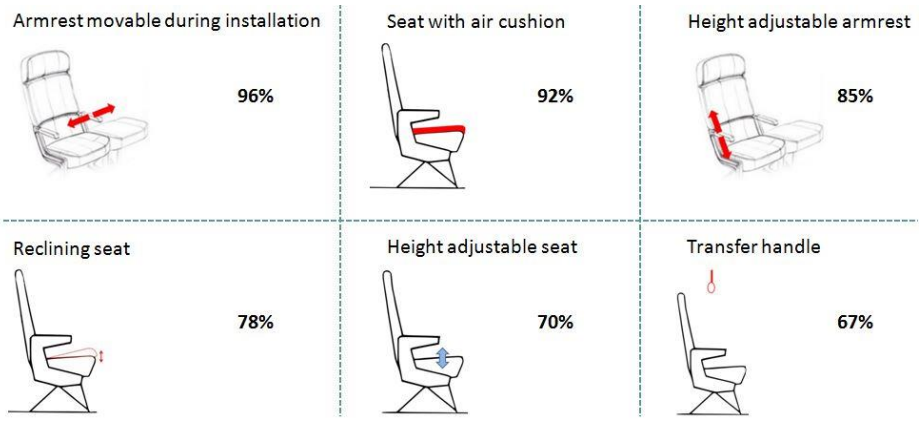
Among those participants, 3 participants expressed their inherent difficulties regarding the seated stability during the flight, landing and turbulence. 1 participant expressed his difficulty concerning the takeoff. Participant had to hold itself to the armrest and to the backrest in front.

During the flight, 1/3 participant had lack of balance and feel discomfort in the seat. 1/3 participant used its pressure sore cushion and felt uncomfortable in the seat because with the cushion the curvature of the backrest was not appropriate. The participant felt pression within its back. 1/3 participant had to adjust its posture during the flight.
During turbulence, 2/3 participants had a bad posture and had to change their position in the seat. 1/3 participant had to lean on the armrest and the bakrest in front. During landing, 1/3 participant had to lean on the armrest and the bakrest in front. 2/3 participants were thrown forward.

c. Adaption

Figure 4 represents the percentage of participant who would appreciate each adaptation from armrest movable during installation to transfer handle. The data analysis shows that the favorite adaptations are the movable armrest during installation and the seat with air cushion. More than 90% of participants would like to profit of these modifications (Fig. 4). We considered that adaptations that have been chosen by more than 75% of participants are solutions that could be proposed by airlines. Thus both adaptations on armrests and seat with air cushion and reclining seat could be proposed to enhance accessibility or comfort in aircraft seat.

Figure 4: Percentage of participant who would appreciate additional adaptations



Participants highlighted that the availability of armrests can become an obstacle to transfer, especially when they are fixed and non-adjustable. In fact, they perceived these armrests making more complex the performance of sitting transfers as limited obstacle-free space is available. Thus multiple smaller transfers are required to safely reach the target seat. Then both adaptations on armrest could be proposed to improve the transfer of manual wheelchair users.

Both adaptations on seat could be proposed to improve comfort and stability for participants. Reclining seat could raise their legs and improve the stability. Seat with air cushion could improve comfort by playing the role of a pressure sore cushion.

Conclusion

Previous studies (Poria et al., 2010; Grant, 2013) have listed difficulties felt by wheelchair users inside the aircraft. However, these studies did not especially focus on aircraft seat satisfaction and what participants would prefer to improve their comfort, accessibility or stability. This study aimed to quantify the satisfaction level of manual wheelchair users with regard to aircraft seats and to examine their perceptions about potential solutions that could be proposed to improve comfort, accessibility or stability.

Among different types of flight, participants used various seat locations. Among three seat locations within the aircraft (aisle, central, window), the majority of manual wheelchair users mentioned that the window seat was their favorite place. However, even if the window seat is the favorite location, participants estimated that transferring in to this seat is challenging. In addition, in order not to disturb other passengers, participants would rather be on the window seat than the aisle seat, even if the transfer is difficult. Our study is consistent with Poria et al. (2010) which described that wheelchair users often preferred a window seat to reduce contact with other passengers.

Accessibility to the seat is the first step in the plane in order to take a flight. Participants express the need to have a place in the first seat row in order to facilitate the transfer. This preference was also found in Poria et al. (2010) where participants preferred a seat at the front of the aircraft, next to the exit door to benefit of more legroom. A seat in a first row will also avoid the problems associated with their loss of mobility (Darcy, 2012). Also having a place next to the exit door would allow passengers to use their own wheelchair (Campese et al., 2016).

Manual wheelchair users use different transfer strategies, depending on the environmental features (Tsai & Kontz, 2003). Among available strategies, some authors have analyzed the sitting pivot transfer (SPT), as it is reported to be the transfer most widely used (Gagnon et al., 2008). Unfortunately, this strategy is not always possible in a plane because of the restrained space around the aircraft seat surface. In that case, the boarding chair is placed parallel to the seat of the plane, so the subject is unable to realize a SPT. Then benefit of a place in the first row could allow manual wheelchair users to realize the SPT and then make the transfer easier. With this specific location in the aircraft wheelchair users will benefit from a larger pitch that would also decrease the time to leave the seat (Gwynne et al., 2018). Also, physical well-being is determined by the physical fit of the space to the passenger body (Ahmadpour et al., 2016). Thus, this specific place would improve comfort for these users during the flight. Consumers will have more legroom and could stretch their leg to avoid pressure sores. In addition, due to the large space in front of the first row, wheelchair passengers seated in the aisle seat would not be disturbed by the displacement of the other passengers. Furthermore, they could go to the restroom during the flight without annoying other passengers.

Seated stability is another parameter to take in to account for wheelchair users. Indeed, for certain degree of spinal cord injury participants have a lack of stability due to an alteration of their abdominal and lumbar muscle. Their stability is being tested during several step of the flight as takeoff, landing and turbulence (Davies & Christie, 2017). The difficulty experienced by participants during the flight was many kinds. For takeoff they have to hold on with their hands to the backrest of the front seat or to the armrest. During turbulence participants had difficulties keeping their balance. In that case they were unstable and feel uncomfortable in their seat. For landing some participants were thrown forward during brake of the aircraft and had to hold back with the armrests.

In addition to aircraft seat satisfaction, feedback on adaptations was examined in this study. The data analysis shows that all adaptations on armrest came in to the top of the list. This finding is in adequacy with Quigley et al. (2001) who found that the design of armrest was very important for participants getting in to or out of their seat easily. They reported that the armrest close to the boarding chair should be capable of moving to permit a clear access to the seat. Then even if SPT is not possible, adaptation could be proposed to manual wheelchair users in order to facilitate their access to the aircraft seat. This adaptation on armrest could also offer to wheelchair passengers a low physical effort that will improve their comfort (Campese et al. 2016).

Seat with air cushion was also reported as one of the favorite adaptations. This modification on seat surface could contribute to improve comfort of the passengers. Davies & Christie (2017) mentioned that the seat should be padded and have pressure relieving qualities to make it comfortable. For wheelchair travelers, any health issues have to be managed along with the inherent health issues arising from air travel. Then covering the aircraft seat with an air cushion could play the role of pressure sore cushion and prevent skin impairment. This assumption is supported by Darcy (2012) who mentioned that adding a pressure-reducing seating cushion to a person with reduced mobility is essential for posture and to protect skin against pressure. However, installing an air cushion will raise the seat height and would probably make very difficult the aircraft seat access with an aisle chair. Indeed, the height difference between both seat surfaces will be too important for an easy transfer. Thus if an air cushion is added to an aircraft seat, the final surface of the seat needs to be as the same height as the aisle surface seat. In this configuration the transfer for wheelchair travelers will be facilitated. This postulate is confirmed by Spartacus et al. (2018) who found that seat surfaces adjusted to the same height, facilitate the transfer by reducing the number of pelvis displacements. In conclusion, a balance needs to be found between improving comfort, accessibility or stability.

This study is the first contribution to the perception analysis of manual wheelchair users regarding aircraft seat adaptations. However, because the present study included a relatively small and homogenous group of manual wheelchair users, caution is warranted for generalizing the present results to a larger group of the same type of individuals or to individuals with different sensorimotor impairments. Confirmation of these results would require a more heterogeneous group and a larger number of participants particularly to identified adaptations who could be designed and proposed to this type of population. Regarding the questionnaire, the section targeting adaptations on aircraft seat has no statement specifically addressing comfort, accessibility or stability. In this section, it is possible that the respondents may have been favorable to an adaptation with regards to one of the sensations instead of another. We could only assume by the previous responses on the questionnaire that adaptations are made for one criterion. This last point will deserve specific attention in the development of future questionnaires targeting the potential effects of adaptation on comfort, accessibility or stability.

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