



An investigation of factors affecting the performance of wheelchair transfers

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An investigation of factors affecting the performance of wheelchair transfers

Purpose: Being able to transfer in and out of their wheelchair is an important task for wheelchair users that can be affected by a variety of different factors. The aim of this study was to investigate the interplay between personal characteristics, wheelchair users' transferring technique and the other factors that can affect the performance of wheelchair transfers.

Method: A cross-sectional survey study was designed to recruit wheelchair users, aged 18 or older, performing sitting-pivot or standing-pivot wheelchair transfers, independently or with assistance.

Results: 42 usable surveys were returned. Transferring technique is usually determined by the individual's impairment. In turn, transferring technique will greatly affect the perceived difficulty of different types of wheelchair transfers and, the number of transfers that people will perform in a day. The presence of upper limb pain increased the difficulty reported for certain types of transfers while the use of assistive technologies appears to be only partially successful in facilitating the performance of wheelchair transfers.

Conclusion: This study highlights the complexity of the factors included in the performance of wheelchair transfers. Findings from this survey can be utilised to broaden the boundaries of future research.

Keywords: wheelchair transfers; survey; assistive technologies; upper limb pain

Introduction

Wheelchair transfers are one of the most important activities in the lives of wheelchair users [1,2]. Wheelchair users represent an extremely broad and diverse group that includes people with different medical conditions, demographic characteristics, lifestyles, needs, difficulties and goals [3]. Depending on their individual characteristics, some people will be able to perform wheelchair transfers independently, while others might need partial or complete assistance. Furthermore, some people who

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3 transfer independently might adopt a standing-pivot or a sitting-pivot technique while
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5 others might rely on assistive technologies (ATs) to facilitate their performance [4]. Due
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7 to this diversity, wheelchair users will have different needs and employ different
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9 strategies when transferring to and from their wheelchair. In addition transfers take
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11 place in a different settings.
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13 Previous studies have estimated that, on average, a person with spinal cord injury (SCI)
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15 transfers to and from their wheelchair approximately 15 times a day [5–7]. However,
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17 the number of transfers reported by each individual can vary from 0 to 45 transfers per
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19 day [5]. To our knowledge, no study so far has investigated the causes of such a large
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21 variation.
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24 Several factors can affect the individual's ability to perform wheelchair transfers.
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26 Studies by Dalyan *et al* [8] and Samuelsson *et al* [9] reported that presence and the
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28 intensity of upper limb pain interfered with the performance of wheelchair transfers for
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30 74% and 62% wheelchair users with SCI. Transferring, particularly transferring into and
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32 out of a car, is one of the items on the Wheelchair Users Shoulder Pain Index (WUSPI)
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34 which receives the highest reported intensity of pain by wheelchair users [10].
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37 However, these studies give us no indication of how pain impacts the performance of
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39 wheelchair transfers; nor if and how people with different impairments are affected by
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41 the presence of pain during transfers.
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44 Several studies have also identified how different types of wheelchair transfers
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46 (wheelchair-toilet, wheelchair-car, wheelchair-bed) can be more or less difficult for the
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48 individual and potentially lead to increased physical effort [11,12]. Additionally, Toro
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50 *et al* [13] measured the influence of different environmental factors such as height
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52 difference, gap dimensions, the presence of an obstacle, the presence and height of a
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54 frontal or lateral grab bar on the performance of wheelchair transfers. Results indicated
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3 how height difference between wheelchair and target seat, both higher and lower, and
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5 the presence of an obstacle had the greatest impact on the participant's ability to
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7 transfer. Placing a grab bar in front of the target seat helped approximately 20% of the
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9 individuals during several of the transfers performed. Although results from these
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11 studies might be helpful to understand objective difficulties that wheelchair users in
12
13 general encounter when transferring in the built environment, they fail to consider how
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15 these difficulties might vary across participants using different transferring techniques.

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18 Few studies have taken into account the use of ~~Assistive Technologies (ATs)~~ in the
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20 evaluation of wheelchair transfers [14] and none of them have investigated the
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22 likelihood of transfer's ATs use among people with various levels of independence nor
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24 how the use of ATs impacts the perceived difficulties of wheelchair transfers. Finally,
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26 psychological factors such as confidence and self-efficacy have also been demonstrated
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28 to have an important effect on performance level during wheelchair sports [15].
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30 Furthermore, studies from Best *et al* [16] and Sakakibara *et al* [17] have shown how
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32 increased confidence and self-efficacy of manual wheelchair skills results in improved
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34 performance that positively affect participation. Wheelchair transfers are described as
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36 an important and challenging activity for many wheelchair users [1,11] but how does
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38 the level of independence and the technique used by the individual affects self-
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40 confidence and satisfaction?
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44 Most studies on wheelchair transfers have focussed on one aspect related to the
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46 performance of wheelchair transfers such evaluating the impact of upper limb pain [10]
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48 or transfer set up and environmental constraints [13]. Moreover, the majority of
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50 available studies either focuses on the performance of independent sitting transfers
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52 performed by people with SCI [18] or generalises findings across many wheelchair
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3 users regardless of their level of independence and the technique used when
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5 transferring.

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7 This study has a two-fold aim. The first is to identify general characteristics of
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9 wheelchair users who perform wheelchair transfers with various levels of independence
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11 and using different transferring techniques. The second aim is to explore which factors
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13 affecting the performance of wheelchair transfers are dependent on the transferring
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15 technique adopted by the individual and which factors are relevant regardless of how
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17 the transfer itself is performed.
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19 20 21 **Method**

22 23 *Materials and Procedure*

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25 A five section cross-sectional self-administered survey was purposefully designed by
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27 the authors for the study. The questionnaire was developed based on a literature review
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29 concerning factors that can potentially influence the performance of wheelchair
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31 transfers, such weight, type of impairment, transferring technique, need for assistance,
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33 use of ATs and context of the transfer [13,19–22]. Additionally, as it was hypothesised
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35 that perceived competency and self-efficacy in might directly affect the performance of
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37 wheelchair transfers, four questions from the Intrinsic Motivation Inventory [23] were
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39 included in the questionnaire. A multiple choice response format was developed for the
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41 majority of questions to reduce time and burden of participation [24][23]. These
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43 questions required participants to use a 7 point scale to report their response. To
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45 maintain consistency, as the Intrinsic Motivation Inventory [23] features rating
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47 questions using a 7 point Likert scale, all rating question throughout the survey used the
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49 same format . At the end of the questionnaire an open ended question was added, asking
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51 for additional comments, insights or feedback from respondents. The survey was
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~~distributed in electronic form and potential participants were recruited by through advertisements in UK based charities newsletters, websites and social media. Additional participant calls were made by posting on forums for wheelchair users, placing flyers in rehabilitation centres and word of mouth. Inclusion criteria for the study were: aged over 18 years and use of a wheelchair as a primary mean of mobility (both self-reported). The landing page included an informed consent form and participants were able to access the survey once they had agreed to participate.~~

The survey was not tested for validity and reliability prior to use. However, to ensure readability and accessibility an earlier version of the surveyThe questionnaire was pilot tested with a small group of both manual and powered wheelchair users (n = 10) that had different medical conditions and performed different types of wheelchair transfers with various degrees of assistance. According to their feedback, two additional items were introduced and some minor changes in the wording of three questions were implemented in order to improve clarity. The final survey contained 23 items divided into five sections:

- (1) Demographic Information (8 Questions): General characteristics of the respondent were collected in this section including the subject's gender, age, weight, height, ~~and the~~ experience as a wheelchair users (in months and years), the primary medical condition, the primary type of wheelchair used and any additional wheelchairs used.
- (2) Wheelchair Transfer Characteristics (5 Questions): Questions in this section explored general characteristics of wheelchair transfers normally performed by the respondent such as the need for assistance during transfers, the use of a sitting-pivot vs standing-pivot technique, the number of transfers performed on a daily basis, the type of transfers normally performed (bed, bathroom, or other

transfers in the house, car and also transfer between wheelchairs) and the perceived difficulty for type of transfers performed.

- (3) Use of Assistive Technologies (6 Questions): Items in this section were divided into two parts. In the first part, respondents were asked to report the use of different ATs for wheelchair transfers (transfer boards, hoists, grab bars, fitted modifications such as swivel seats or other ATs) and to categorise their use according to the different types of transfers normally performed. ~~The first, assessed the use of various ATs categorized by the type of wheelchair transfer performed.~~ The second part, captured an overview of the main advantages and difficulties of using ATs, the self-reported ease of use for each reported AT and motivations for non-use.
- (4) Presence and Intensity of Pain (3 Questions): This section consisted of two items aimed at assessing the presence location (shoulder, elbow, wrist, hand or other) and intensity of upper limb recurring pain within the last six months. Additionally, a third question was added to explore the frequency of pain exacerbated by wheelchair transfers.
- (5) Wheelchair Transfer Motivation (1 Question): This section evaluated four sections of the Intrinsic Motivation Inventory [23][24], namely: importance attributed to the task/skill level, the effort invested in the performance, the perceived competence of the subject and the pressure related to the activity execution.

The survey was distributed in electronic form and potential participants were recruited by through advertisements in UK based charities newsletters, websites and social media. Additional participant calls were made by posting on forums for wheelchair users, placing flyers in rehabilitation centres and word of mouth. Inclusion criteria for the

study were: aged over 18 years and use of a wheelchair as a primary mean of mobility (both self-reported). The landing page included an informed consent form and participants were able to access the survey once they had agreed to participate.

Data Analysis

Data from completed surveys were analysed using IBM SPSS Statistics Version 22 (IBM Corporation, NY, USA). Descriptive statistics were calculated in order to illustrate demographic and general characteristics of the respondents, types of transfers performed, advantages and disadvantages of ATs. Respondents were divided in 3 primary groups according to the level of assistance needed when transferring and their transferring technique (independent sitting transfers, independent standing transfers, assisted transfers). Associations between wheelchair users' demographic characteristics and transferring technique and level of assistance were explored using cross tabulation and a Chi-squared test. ~~A one-way analysis of variance (ANOVA) was used to determine the impact of assistance and technique on the frequency of wheelchair transfers performed on a daily basis.~~ Data related to the daily frequency of transfers was checked for normality using the Saphiro Wilk test. Due to the non-normality of the data across different groups a Kruskal-Wallis test was used to determine the impact of technique and assistance on the frequency of wheelchair transfers performed on a daily basis. A chi-squared test was employed to investigate the association between participants' technique, presence of pain and AT use. A Kruskal-Wallis test was used to analyse the impact of transfer technique and independence on intensity of pain, reported difficulty, individual's motivation and self-satisfaction. Where significant differences were found Tukey test was used for ANOVA post hoc analysis and Dunn's test with Bonferroni correction for Kruskal-Wallis pairwise comparison, while standardised residuals were examined for Chi-squared tests. Statistical tests were chosen

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3 according to the type of independent variable: ANOVA for continuous variables,
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5 Kruskal-Wallis test for ordinal variables and chi-squared test for nominal variables.
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7 Spearman's correlation was used to assess the relationship between satisfaction with
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9 transfer performance and reported difficulty across different transferring techniques.
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11 Lastly, independent t-test were employed to assess the impact of participant's weight on
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13 the likelihood of AT use during transfers. Level of significance for all statistical tests
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15 was set at .05.
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18 19 **Results**

20 21 *Participants*

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23 A total of 42 fully completed surveys were returned. Demographic characteristics are
24
25 presented in Table 1. The median age of the respondents was 46.5 years, ranging from
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27 19 to 67 (IQR = 22). Median self-reported weight and height were, respectively 72.3 kg
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29 and 172.7 cm, ranges spanned between 30.4 kg to 120 kg (IQR = 33.3) and 122 cm to
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31 195.6 cm (IQR = 21). Respondents were on average very experienced wheelchair users,
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33 nearly 55% had more than 10 years of experience. Median number of years of
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35 experience as a wheelchair users was 13.25. Primary medical conditions varied greatly
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37 across respondents. The most common reported diagnosis was SCI, followed by MS
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39 and cerebral palsy (CP). However, over 35% of the respondents had other medical
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41 conditions which affected their mobility including Ehlers-Danlos Syndrome, muscular
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43 dystrophy and post-polio paralysis. Respondents were mainly manual wheelchair users,
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45 with only 30% reporting powered or pushrim activated power assisted wheelchairs
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47 (PAPAW) as a primary mean of mobility. Twenty-seven respondents also reported the
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49 ownership and use of other wheelchairs and mobility devices, including scooters, sport
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51 wheelchairs and add-on hand bikes. From cross tabulation of demographic factors the
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3 sample appears very homogeneous, with even distribution of age groups and physical
4 characteristics across different medical conditions and primary wheelchair type. More
5 clear relationships were instead found between medical condition and type of primary
6 wheelchair used, with the totality of respondent who reported a low level SCI using
7 rigid and foldable frame wheelchairs as a primary mean of mobility.
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13 **Table 1**

14 15 16 17 ***Wheelchair users characteristics according to level of independence and*** 18 ***transfer strategies***

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20 Thirty-one (73.8%) of the respondents reported being able to transfer without any
21 assistance. Of these 23 (74.2%) performed sitting-pivot transfers while 8 transferred
22 using a standing-pivot technique. Seven participants (16.7%) stated that they usually
23 need some assistance in order to safely transfer in and out of their wheelchair and 6
24 (85.7%) used a sitting-pivot technique. Only 4 respondents, accounting for 9.5% of the
25 total population, defined themselves as completely dependent when performing
26 wheelchair transfers and no one transferred using a sitting-pivot technique. Due to the
27 low number of participants performing assisted and dependents transfers, their
28 responses were combined while independent wheelchair transfers were categorised
29 according to the technique (sitting-pivot or standing-pivot) used by the individual. A
30 significant relationship was found between individuals' medical condition and
31 transferring strategy $\chi^2= 32.43$, and $p < 0.001$. Over 60% of the respondents performing
32 independent sitting-pivot wheelchair transfers reported having a SCI that only affected
33 their lower limbs, while 74.1% of the tetraplegic participants stated that they needed
34 partial or complete assistance when performing transfers. All participants with CP
35 performed independent standing-pivot transfers while respondents with other, various
36 medical conditions were more evenly spread across the 3 transferring techniques. No
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3 significant association was found between participants' transferring technique and
4 primary type of wheelchair used ($p = .07$) or individuals' body weight ($p = .316$).
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7 Figures 1, 2 and 3 show the distribution of participants' characteristics across the 3
8
9 transferring techniques.

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11 **Figure 1**

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13 **Figure 2**

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15 **Figure 3**

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19 ***Frequency of transfers, types of transfers and reported difficulty***

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22 The median number of transfers performed daily by respondents was 8 (IQR = 5.3).
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24 There was a statistically significant difference between transferring technique groups as
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26 determined by the Kruskal Wallis Test ($\chi^2(2) = 8.128, p = .017$). A Dunn's post-hoc
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28 test with Bonferroni correction revealed that the daily frequency of transfers was
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30 significantly lower for participants who needed assistance (median = 4, IQR = 5, $p =$
31
32 .016) compared to participants who performed independent sitting transfers (median =
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34 8, IQR = 9). The median number of daily transfers reported by participants performing
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36 independent standing transfers was 7.5 (IQR = 3.5) but the difference was not
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38 significant when compared to the other 2 groups (lowest $p = .37$). Participants performed
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40 on average 9 wheelchair transfers per day (STD ± 7). The number of transfers per day
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42 was significantly difference between transferring technique groups as determined by
43
44 one-way ANOVA ($F(2, 39) = 4.088, p = .024$). A Tukey post hoc test revealed that the
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46 daily frequency of transfers was significantly lower for participants who needed
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48 assistance (4.6 ± 2.4 min, $p = .022$) compared to participants who performed
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50 independent sitting pivot transfers (11.6 ± 8.8 min). Participants performing
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52 independent standing pivot transfers reported an average of 7.6 ± 2.5 transfers per day
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54 but the difference was not significant when compared to the other 2 groups (lowest $p =$
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~~34)~~

When asked about the different types of transfers routinely performed, all respondents reported performing bed to wheelchair transfers and various transfers from and to the wheelchair when in the bathroom (e.g. toilet, shower, commode chair) on an everyday base. Car transfers were also very common, with 76.2% of respondents performing them daily, other house transfers (e.g.: couch, dining table) were slightly less common 64.3%, while transfers between different wheelchairs were a regular occurrence for 69% of the respondents. Additionally, thirteen participants reported frequent transfers onto office chairs, restaurants and/or cinema seats, plane seats and various exercise or rehabilitative devices such as hand bikes and standing frames.

When looking at the types of transfers performed by individuals by transferring technique group, we found that car transfers were performed by 91.3% of the participants using an independent sitting-pivot transferring technique. Respectively, only 62.5% and 54.5% of wheelchair users performing standing-pivot and assisted transfers reported regular transfers to and from car seats. Similarly, people using an independent sitting-pivot technique were more likely to perform house transfers (69.6%) compared to individuals performing independent standing-pivot transfers (62.5%) or assisted transfers (54.5%). Transfers between wheelchairs were common practice for all respondents using an independent standing-pivot technique while they were performed by only 65.2% of individuals using independent sitting-pivot technique and 54.5% of people performing assisted transfers.

Participants were also asked to rank the level of difficulty of each transfer they routinely perform on a Likert scale from 1 (Very Easy) to 7 (Very Hard). When considering all participants within a single group, bed transfers were considered the easiest among the more frequent transfers (Mean 2.74, STD \pm 1.71). House transfers are

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2 also performed with moderate ease (Mean 3.00, STD \pm 1.47), while bathroom transfers,
3 transfers between wheelchairs and car transfers appear as a more challenging scenarios
4 (Means 3.76, 3.79, 3.94, STDs \pm 1.88, 1.92, 1.95). People who reported additional
5 routine execution of other transfer types, in addition to the five basic scenarios we
6 proposed (bed, bathroom, car, house and between wheelchairs), rated them as generally
7 easy (Mean 2.62, STD \pm 1.39). When responses were examined separately according to
8 participants' transferring technique, it was observed that reported average difficulties
9 were lower for individuals performing independent sitting transfers across all
10 conditions. Kruskal Wallis Test shows a statistically significant difference between
11 groups for bed ($\chi^2(2) = 10.317$, $p = .006$), car ($\chi^2(2) = 2.564$, $p = .020$), house ($\chi^2(2) =$
12 12.03 , $p = .002$) and other transfers ($\chi^2(2) = 7.5$, $p = .024$). Post hoc analysis revealed
13 how all transfers were considered significantly easier by participants using an
14 independent sitting-pivot technique compared to individuals who required assistance
15 (bed transfers $p = .009$, car transfers $p = .016$, house transfers $p = .002$, other transfers p
16 $= .041$). Figure 4 shows the mean difficulty reported for different types of transfers by
17 respondents using different transferring techniques.
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37 [Figure 4](#)

38 ***Presence and influence of pain on transfer performance***

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41 As expected, painful symptomatology in one or more areas of the upper limbs was
42 reported by the majority of the respondents. Complaints of shoulder and wrist pain in
43 the previous six months were the most common, affecting respectively 69% and 52.4%
44 of the respondents. Frequencies of hand and elbow discomfort were only slightly lower,
45 respectively 50% and 42.9%. Additionally, 52.4% of participants reported recurring
46 pain in other body locations such as neck, back and buttocks. The relationship between
47 upper limb pain and wheelchair transfer was confirmed by the fact that 66.6% of the
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3 respondents complained that their pain was exacerbated by wheelchair transfers at least
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5 occasionally. Average intensity of pain, was moderately high for all upper limb's
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7 districts pain with values ranging from 4 at the elbow to 4.45 at the wrist.
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9 Chi-squared test revealed no significant association between presence of pain during
10
11 transfers, and the technique used for transferring ($p = .236$). Furthermore, Kruskal
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13 Wallis Test confirmed that there was no significant relationship between the wheelchair
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15 users' transferring technique and the intensity of shoulder ($p = .311$), elbow ($p = .680$),
16
17 wrist ($p = .550$) and hand ($p = .974$) pain. The presence of upper limb pain during
18
19 transfers did not significantly affected the number of daily transfers for individuals
20
21 performing independent sitting ($p = .765$), independent standing ($p = .656$) or assisted
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23 transfers ($p = .082$). Overall, participants who complained of frequent upper limbs pain
24
25 during transfer performance generally reported higher level of difficulty for all transfer
26
27 types. However, this difference was deemed significant only for bed ($\chi^2(3) = 8.417, p =$
28
29 $.038$) and house transfers ($\chi^2(3) = 9.023, p = .029$). Post-hoc analysis showed that in
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31 both cases the differences were only significant when comparing respondents whose
32
33 pain is always exacerbated by transfers and the other three groups (highest significant p
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35 $= .043$).

40 41 ***Motivation and satisfaction with transfer performance***

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43 Over 88% of respondents considered transferring skills extremely important, giving the
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45 maximum score of 7 on the provided Likert scale. This was further confirmed by the
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47 fact that, when asked about the effort invested in the task, 85.7% of the respondents
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49 stated that they invested great effort in performing wheelchair transfers safely and
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51 effectively (Score 6 and 7 on Likert scale). Participants were generally, satisfied with
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53 the way they transferred in and out of their wheelchair and they felt reasonably secure
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55 during the performance. However, 16.7% of respondents were unsatisfied with their
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3 skills (1-3 points on Likert scale) and 28.6% felt extremely tense during wheelchair
4 transfers (Score 6 and 7 on Likert scale). Transferring technique and need for assistance
5 did not seem to impact the importance people attributed to wheelchair transfers ($p =$
6
7 .137), the satisfaction with their ability ($p = .17$) nor the perceived stress during
8
9 wheelchair transfers ($p = .119$). However, a significant relationship was found between
10
11 the transferring technique used by the participant and the effort invested in performing
12
13 safe transfers ($\chi^2(2) = 7.575, p = .023$). Dunn's test showed that participants performing
14
15 independent sitting-pivot transfers tried harder to perform safe transfers (6.65 ± 1.08)
16
17 compared to participants using an independent standing-pivot technique (5.75 ± 1.39
18
19 min, $p = .019$) and participants performing assisted transfers (5.73 ± 1.95 min, $p = .039$).
20
21 Regardless of their transferring technique, participants who reported increased
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23 difficulties for various types of transfers were less likely to be satisfied with their
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25 transferring skills ($r = -.505, p < .001$). Furthermore, pain during transfer also had an
26
27 effect on how nervous respondents felt during transfer performance ($\chi^2(3) = 9.788, p =$
28
29 .020). Post hoc analysis revealed how differences in the level of perceived insecurity are
30
31 significant only for respondents complaining of occasional pain during transfers ($2.95 \pm$
32
33 2.16 min, $p = .012$) and respondents reporting constant pain during transfers ($5.88 \pm$
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35 1.25).

42 43 *Use and needs for ATs*

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45 The vast majority of respondents, 73.8%, declared to benefit, in one or more situation,
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47 from the use of an ~~AT assistive technology~~ or from the presence of environmental
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49 modifications such as swivel seats or adapted vehicles. Overall, grab bars were the most
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51 commonly adopted, used by 42.9% of participants, followed by transfer board, hoists,
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53 environmental modifications and other less common devices. . However, the type of
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55 transfer for which each ~~assistive technology~~AT is usually employed differ from one
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3 device to the other. Grab bars were found almost exclusively within the house,
4 particularly in the bathroom. Only four individuals declared having special handles
5 mounted in their car in order to ease their transfers. On the other hand, the use of
6 transfer boards was slightly more common for car transfers (33.3%), compared to bed
7 (23.3%) or other house transfers (20%). As expected, hoists were found only within the
8 house and used mainly for bathroom, bed, house or transfers between different
9 wheelchairs. Reported environmental modifications concerned adapted vehicles in
10 66.7% of cases and hospital beds in the remaining 33.3%.

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20 We found no significant relationship between the likelihood of AT use and the
21 transferring technique adopted by the subject ($p = .28$). Surprisingly, the choice of AT
22 was only mildly affected by the individual's transferring technique. Transfer boards
23 were more common among participants performing independent sitting-pivot transfers,
24 while grab bars used more by participants who transferred while standing up. However,
25 the difference in AT distribution was only significant for hoists which were used almost
26 exclusively by people needing assistance for transferring ($p = .025$). Regardless of
27 participant's transferring technique, no association was found between the presence of
28 pain during transfers and the use of ATs. However, as shown in Figure 5, participants
29 who reported use of various ATs during transfers were found to be significantly heavier
30 (78.603 ± 22.186) than participants who transferred without using any AT ($63.764 \pm$
31 16.256) $t(40) = -2.027$, $p = .049$.

32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 **Figure 5**

47 48 49 **Discussion**

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52 Most studies on wheelchair transfers have focussed their efforts towards attempting to
53 isolate and explain individual variables that affect the performance of wheelchair
54 transfers such as the presence of upper limb pain [10], the configuration of the transfer
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3 set-up [13] or the impact of specific aspects of the physical impairment affecting the
4 individual [25]. As noted by Crytzer *et al* [21] this approach is not sufficient to capture
5 the complexity of aspects that can affect the ability of an individual to perform
6 wheelchair transfers. To our knowledge, this is the first study attempting to take a more
7 comprehensive look at the various factors that can affect the performance of wheelchair
8 transfers and explore the potential relationships among them.

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11 Barbareschi *et al* [19] show how the use of different transferring techniques can have a
12 great impact on the safety of the transfer and the mechanical loading on the upper limbs.
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14 As transferring technique plays such an important role in the performance of wheelchair
15 transfers, the first aim of this study was to analyse the individual characteristics that are
16 associated with the performance of sitting-pivot, standing-pivot and assisted transfers.
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18 Results from our survey showed that primary medical condition is the main factor that
19 determines the movement strategy adopted by the person when transferring. As weight
20 has been shown to significantly decrease the functional abilities of many wheelchair
21 users [26], we expected individuals with higher bodyweight to be more likely to require
22 assistance during transfers. However, our findings show that, while greater bodyweight
23 increased the likelihood of ATs use, it had no impact on the transferring technique used
24 by participants nor it affected their need for assistance. Results from the survey
25 confirmed the fact that transferring technique had an important impact on the
26 performance of wheelchair transfers in real life. However, we identified several aspects
27 that were crucial for all wheelchair users, regardless of the way in which they
28 transferred.

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31 In the survey carried out by Fliess-Douer *et al* [1], wheelchair users with
32 different impairments, lifestyles and abilities agreed in rating transfers as the most
33 essential skills in everyday life. Our study shows similar results with 88% of
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3 respondents attributing crucial importance to their ability to transfer. Despite the fact
4 that the importance attributed to the task was consistent across all wheelchair users, we
5 found that individuals performing independent sitting wheelchair transfers reported
6 investing more effort in ensuring the safety of their transfers. Wheelchair users who
7 need assistance during transfers might be more likely to rely on their caregivers to make
8 sure that transfers are performed in a safe and efficient manner. On the other hand, we
9 believe that the scarcer safety consideration by wheelchair users performing standing
10 transfers might be related to their lack of awareness. Most wheelchair users are likely to
11 learn about the importance of using efficient and safe technique when transferring
12 during rehabilitative training. Wheelchair skills, and transfers, training are considered
13 an important part of rehabilitation for individuals with SCI [27], who represented a
14 substantial portion of the participants performing independent sitting-pivot transfers.
15 Respondents performing independent standing-pivot transfers were individuals with CP,
16 MS and EDS which makes them less likely to have received comprehensive wheelchair
17 transfers training. Without proper training they might have limited knowledge of how to
18 best perform safe and efficient transfers and be less aware of the potential risks
19 associated.

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Reported perceived difficulty of different transfer type was mostly in line with
results presented by Janssen *et al* [12], who measured physical strain, based on
individual's heart rate, of several ADL including various wheelchair transfers. Transfers
to the car seat and to a shower wheelchair were identified as more strenuous activities,
while toilet and bed transfers appeared to be less demanding. In our study, participants
identified car transfers and transfers between wheelchairs as more difficult to perform,
however bed transfers were considered significantly easier than bathroom transfers.
Differences could be due to different experimental set ups, as Janssen *et al* [12] asked

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3 participants to perform transfers in a series of standardized environment while we asked
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5 people to evaluate the transfers they perform in their own home. Additionally, Janssen
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7 *et al* [12] evaluated three bathroom transfers (toilet, shower bench and shower chair)
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9 separately, while in our study they were grouped together as bathroom transfers which
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11 might have been confusing for respondents. Transferring technique was found to have
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13 an important impact on the perceived difficulty of wheelchair transfers. Unsurprisingly,
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15 participants who needed assistance for transferring reported consistently higher scores
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17 for transfer difficulty across different transfer types. On the other hand, we expected
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19 participants who were able to perform independent standing transfers to report lower
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21 difficulties than participants who relied on their upper limbs for transferring. However,
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23 even if they are able to reach a standing position, many wheelchair users will lack both
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25 lower limbs' strength and balance. This is likely to make their transfers more
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27 challenging, despite the fact that their physical impairment appears to be less severe
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29 compared to people who need to fully rely on their upper limbs for transferring.
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31 Overall, the average number of transfers performed daily by our respondents was lower
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33 than reported in literature. However, in the study carried out by Curtis & Black [5] and
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35 Finley *et al* [6] included only paraplegic respondents able to perform independent
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37 wheelchair transfers. Unsurprisingly, participants who required assistance reported the
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39 lowest number of transfers per day. The combination of increased difficulty and their
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41 need to rely, at least partially, on caregivers' help, made them more likely to only
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43 perform transfers that were essential to them. Similarly, we hypothesize that the higher
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45 difficulty reported by individuals performing standing transfers is at least partially
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47 responsible of the reduced number of transfers carried out in a day.
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52 The incidence of upper limb pain among our respondents was consistent with
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54 findings from literature and appeared unaffected by participants' transferring technique
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3 [28,29]. The interference of upper limb pain during transfer performance identified by
4 Samuelsson *et al* [9] was confirmed by the fact that over 66% of participants reported
5 that pain was often exacerbated by the performance of wheelchair transfers. On the
6 other hand, as noted by Finley *et al* [6] the presence of upper limb pain did not have any
7 significant effect on the number of wheelchair transfers performed in a day. As
8 previously highlighted, the ability to transfer in and out of their wheelchair is crucial for
9 the individual's independence. For this reason, wheelchair users might chose to endure
10 the pain caused by the task in order to not lose their independence. The presence of
11 upper limb pain was also shown to affect the perceived difficulty of transfer
12 performance and increased the sense of anxiety people might experience during the
13 performance of wheelchair transfers. This is particularly important considering
14 transfers have a great influence on the overall fear of falling that wheelchairs users
15 might experience [30]. Anxiety might also negatively affect performance and increase
16 the risk of falls as it has been documented for walking, particularly among elderly
17 respondents [31].

18
19 Surprisingly, the choice of using ATs was mostly not affected by the transferring
20 technique of the individual. Additionally, despite the fact that medical guidelines
21 recommend the use of ~~ATs assistive technologies~~ for wheelchair transfers for all
22 respondents experiencing upper limb pain and/or at risk for upper limb injury [18], we
23 found no relationship between the likelihood of AT use and the presence of upper limb
24 pain during transfers. On the other hand, respondents reporting use of ATs were found
25 to weigh more which suggest that ATs are considered a valuable tool when the task
26 becomes physically strenuous. We also found that several people used more than one
27 ~~AT assistive technology~~ and that the choice can be affected by environmental
28 conditions and the type of transfer to perform. Although this was expected for fitted
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3 modifications and non-portable devices, such as wheelchair hoists, the use of transfer
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5 boards was also found to be subjected to this variability. As illustrated in the study
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7 conducted by Haubert *et al* [20], the environmental conditions in which a wheelchair
8
9 transfer is performed will have an important effect on the movement strategy of the
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11 individual and these changes appear to be relevant regardless of the technique or AT
12
13 used.

14
15 Participants found their ~~ATs assistive technologies~~ generally easy to use and reported an
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17 increased level of confidence when performing transfers. Over 83% of the respondents
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19 reported encountering at least one difficulty when using ~~assistive technologies~~ ATs.
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21 Frustrations were mainly related to physical limitations of various devices, including
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23 excessive weight, bulky profile and instability during transfer performance. Inability to
24
25 deal with space constraints, low portability and excessive cost were also among the
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27 most common reasons participants provided to explain why they chose to not use any
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29 ~~assistive technology~~ AT. These findings suggest that the different types of transfers the
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31 individuals perform and the environmental constraints associated with each type of
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33 transfer might affect, beside the transferring technique, also the ability to use
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35 ~~ATs~~ assistive technologies when needed.
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41 **Limitations**

42 This study provided important new data on the relationship between factors that can
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44 affect the performance of wheelchair transfers, however there are limitations that need
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46 to be considered. Although our results appear to agree with finding from larger studies,
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48 due to the small sample size and the limited age range of respondents' generalization of
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50 the results should be carried out with caution. Additionally all our participants were
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52 UK residents and their attitude towards several of the investigated factors, including
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54 pain, need for assistance and ~~assistive technology~~ AT use might be different from other
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3 cultures [32]. Lastly, although we invited people to express comment, concern or
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5 suggestion concerning additional factors that might affect the performance of
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7 wheelchair transfer, the format of an online survey might be too simplistic for such a
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9 discussion. Hence we think the complexity of the phenomenon might benefit from
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11 additional exploration through qualitative and quantitative studies.
12

13 14 15 **Conclusions**

16
17 There are several factors that can affect the performance of transfers in the real world
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19 and it is the combination of these individual factors that makes transfers a challenging
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21 activity for many wheelchair users.
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23 24 Figure 6

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27 ~~As shown in Figure 6~~ transferring technique is usually determined by the individual's
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29 impairment. In turn, transferring technique will greatly affect the perceived difficulty of
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31 different types of wheelchair transfers and, consequentially the number of transfers that
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33 people will perform in a day. On the other hand, the relevance of other factors seems to
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35 be unaffected by the transferring technique used by the person. Concerns about the
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37 impact of transfers on the development of upper limbs injuries and pain are usually only
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39 mentioned for people performing independent sitting-pivot transfers. However, the
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41 presence of pain during transfers' performance appears to be a problem concerning all
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43 wheelchair users. Currently, AT use was found to be unrelated to both transferring
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45 technique and presence of pain during transfers and only linked to increased body
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47 weight. ~~Overall, available ATs are only moderately effective in enabling people to~~
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49 ~~perform wheelchair transfer and they can be cause of frustration for the users due to~~
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51 ~~their high cost and limited functionality.~~
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Table 1 Demographic characteristics of participants

Characteristic	Frequency	Percentage
Gender		
Male	26	62%
Female	16	38%
Age (years)		
18-25	6	14.3%
26-35	4	9.5%
36-45	6	14.3%
46-55	17	40.5%
56-65	8	19.0%
65+	1	2.4%
Weight (kg)		
less than 50 kg	3	7.1%
50-70 kg	17	40.5%
70-90 kg	12	28.6%
90 + kg	10	23.8%
Height (cm)		
less than 165 cm	13	31%
165-180 cm	16	38.1%
180-195 cm	12	28.6%
195+ cm	1	2.4%
Experience as a wheelchair user		
Less than 1 year	2	4.8%
1-5	10	23.8%
6-10	7	16.7%
10+	23	54.8%
Type of primary wheelchair		
MW rigid frame	19	45.2%
MW foldable frame	10	23.8%
Powered wheelchair	11	26.2%
PAPAW	2	4.8%
Medical condition		
SCI (paraplegia)	15	35.7%
SCI (quadriplegia)	7	16.7%
MS	2	4.8%
CP	3	7.1%
Other	15	35.7%

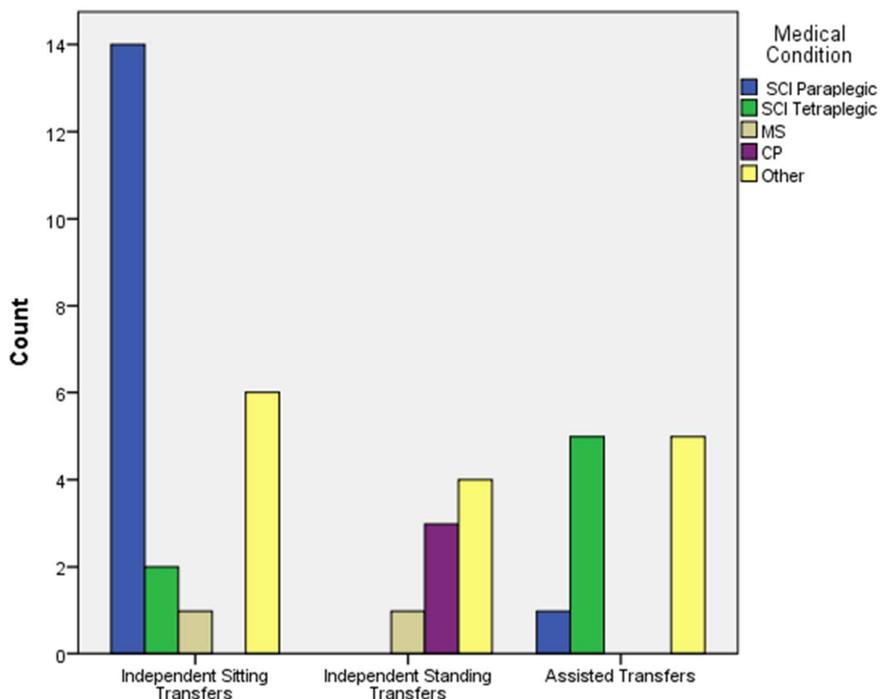


Figure 1 Bar chart showing distribution of participants' medical condition according to transferring technique

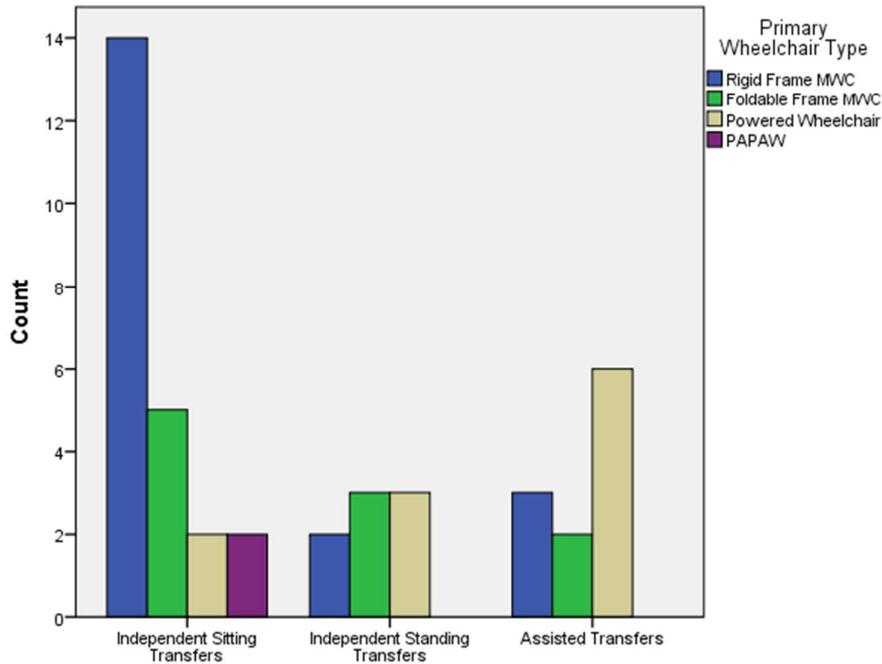


Figure 1 Bar chart showing distribution of participants' primary wheelchair type according to transferring technique

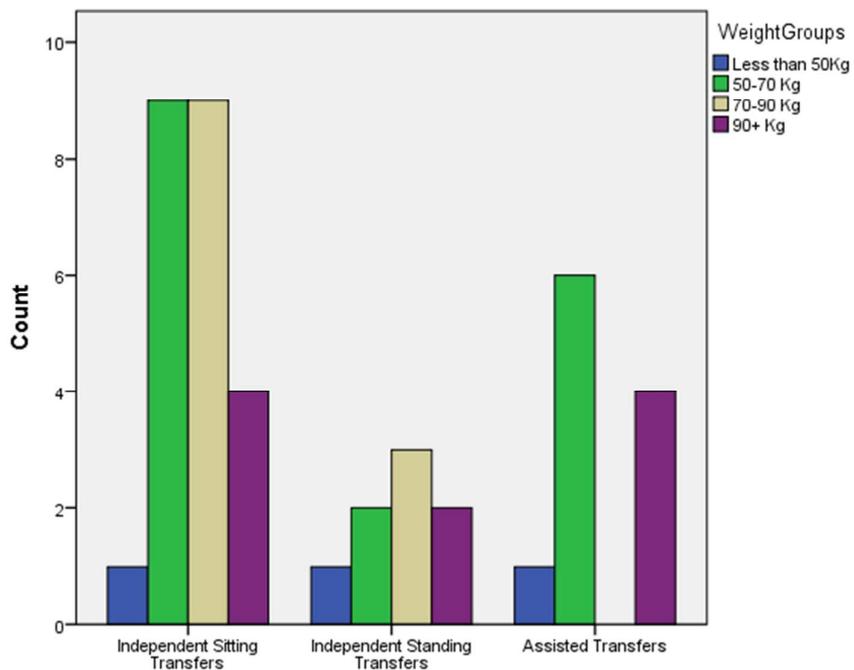


Figure 1 Bar chart showing distribution of participants' weight according to transferring technique

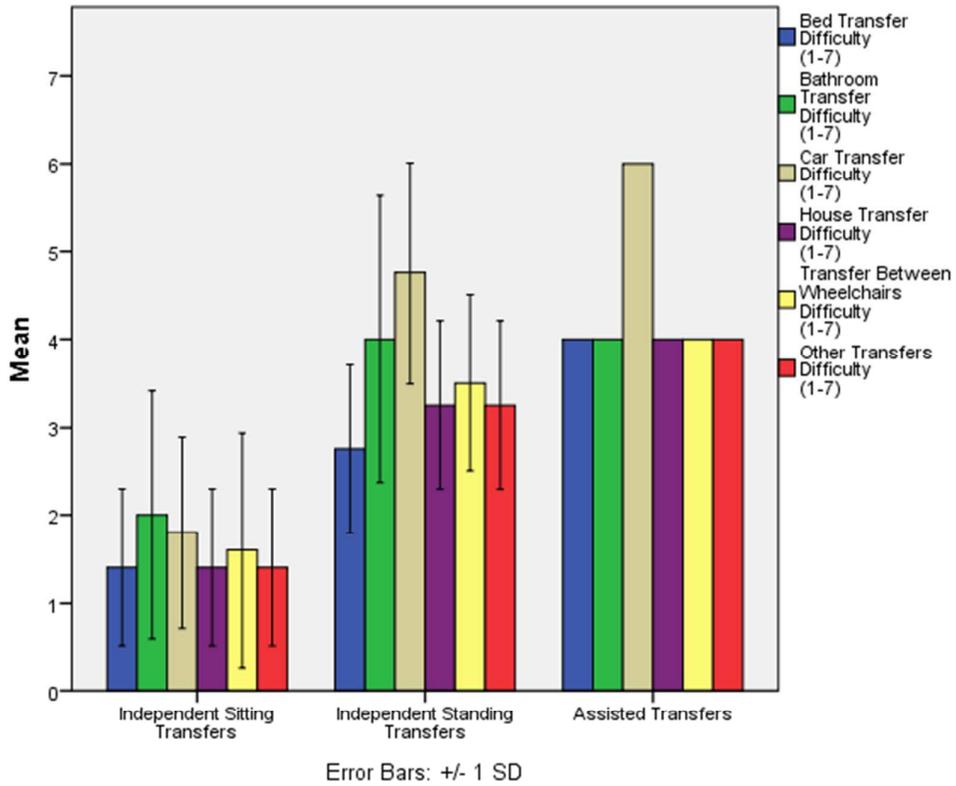


Figure 1 Bar chart showing mean reported difficulty for different types of transfers according to individuals' transferring technique

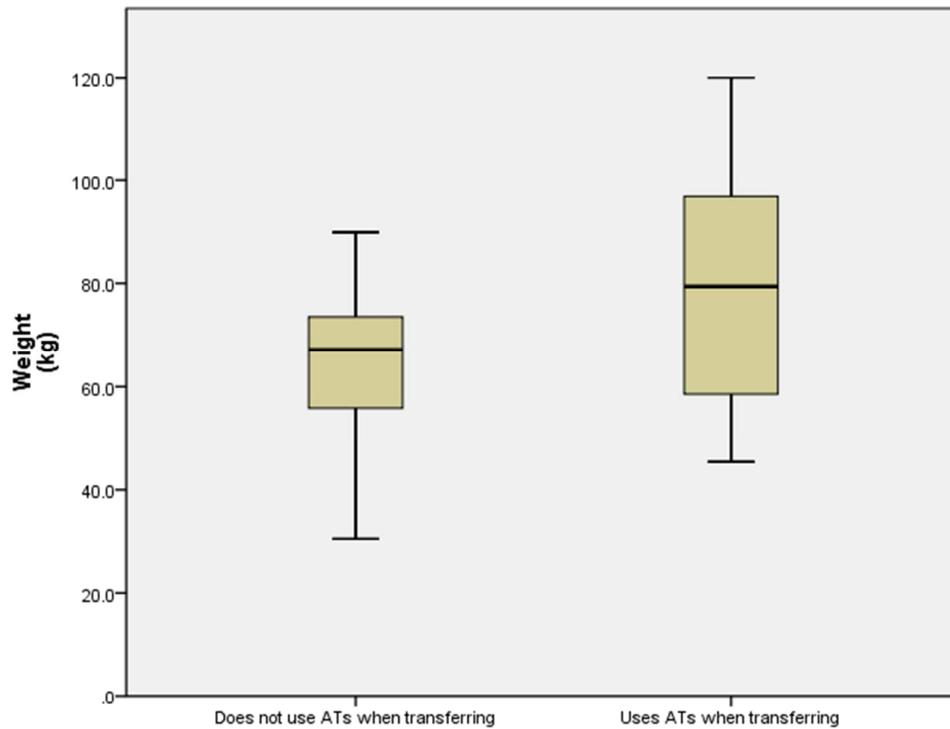


Figure 1 Boxplot showing weight differences between participants who use (or do not use) ATs when transferring

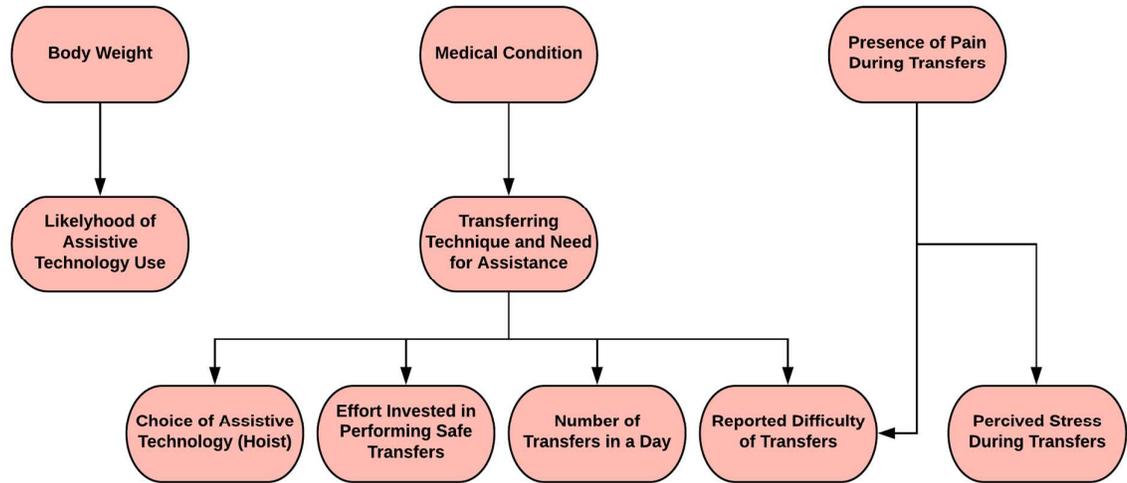


Figure 6 Diagram illustrating all the significant relationships, identified in the current survey, between the various factors related to the performance of wheelchair transfers.

Implications for Rehabilitation

- Transferring technique is usually determined by the individual's impairment. In turn, transferring technique will greatly affect the perceived difficulty of different types of wheelchair transfers and, the number of transfers that people will perform in a day.
- The performance of wheelchair transfers exacerbate the painful symptomatology of the person, regardless of their medical condition or transferring technique. The presence of pain increases the reported difficulty of wheelchair transfers.
- Use of assistive technologies during transfers is linked to the increased body weight of the person, while the choice of the type of assistive technology seems to be dependent of the transferring technique used by the person. Overall, available ATs are only moderately effective in enabling people to perform wheelchair transfer and they can be cause of frustration for the users due to their high cost and limited functionality.

For Peer Review