

A Comparison of Pushrim-Activated Power Assisted Wheels and Traditional Wheels and their Impact on Speed, Effort Levels, and User Perception in the Outdoor Environment

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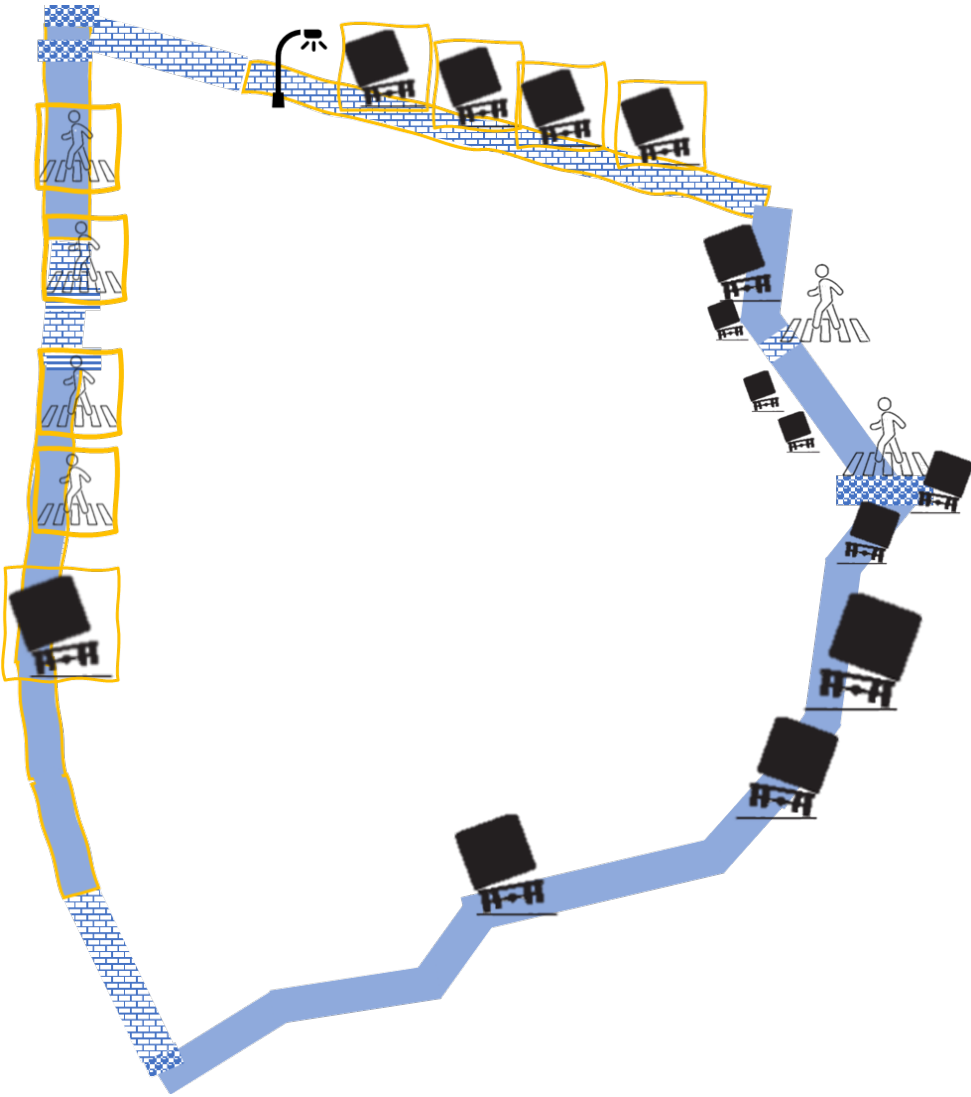


INTRODUCTION

Manual self-propelling wheelchairs have an established prevalence of shoulder injuries but there are few alternatives available without restricting access or mobility. Pushrim-activated power-assisted wheels (PAPAWs) use force-sensor activation data to add propulsion to the wheels, easing the effort of the user in movement. These are not typically provided on the NHS or personal, but the potential benefits in increased distance and reduced effort levels have been explored over the last two decades (typically measured by oxygen consumption or distance travelled). Assessments in real world conditions is an area that is under-researched, this thesis will investigate the use of PAPAWs in the built environment encountering common features (including dropped kerbs, pavement, cambers, hills, road crossings, ramps).

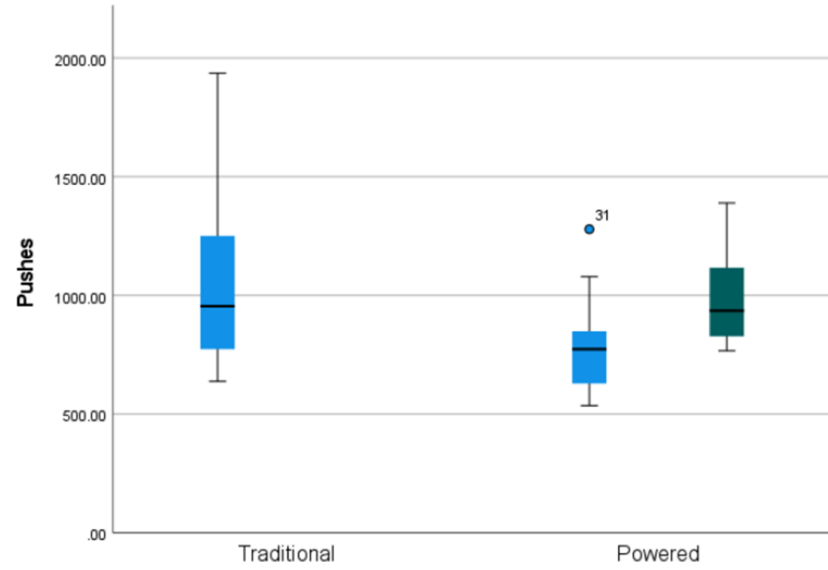
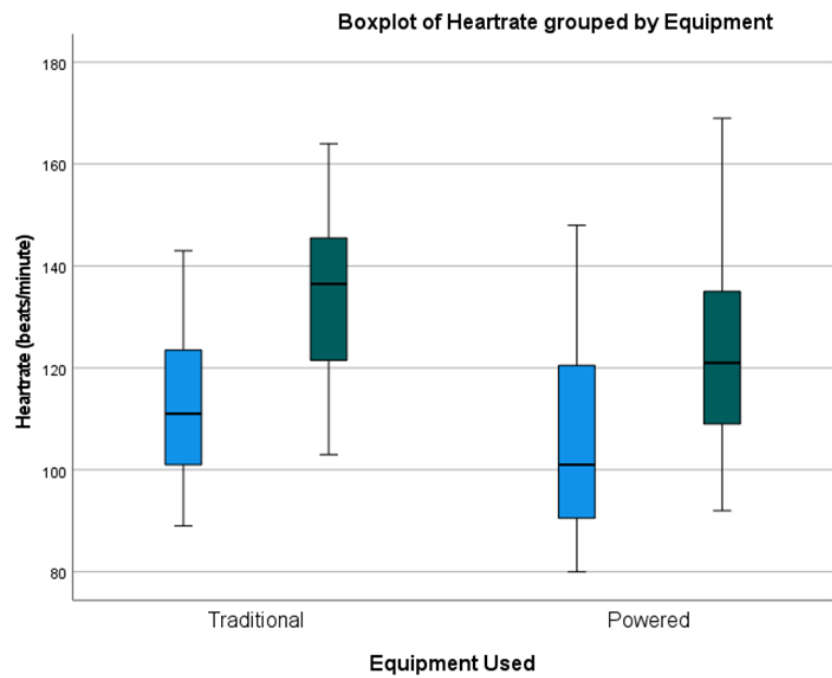
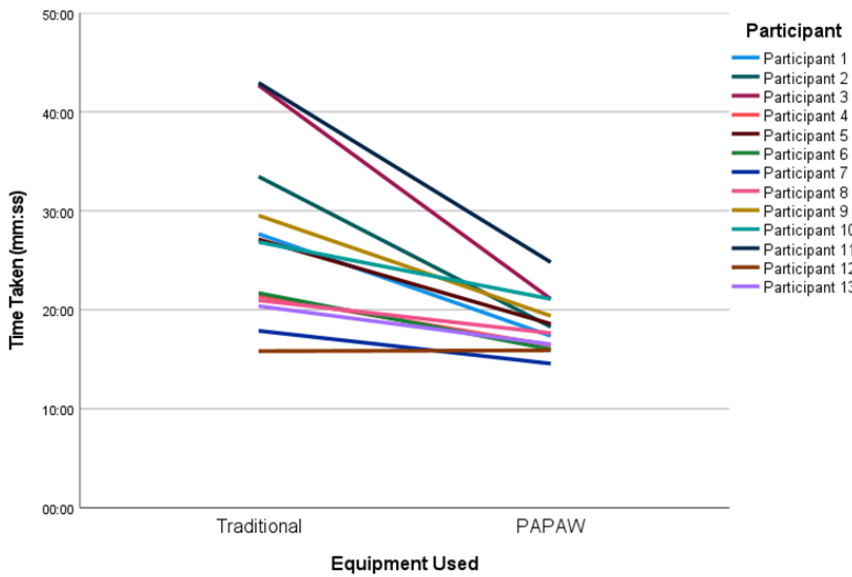
METHODOLOGY

Participants (7 male, 6 female) with a mean age of 31 years, completed a 1km outdoor route in both traditional wheels and PAPAWs (Alber E-motion m25) with their heart rate, time, and push frequency monitored. Counterbalancing was used to control for any order effects. Questionnaires influenced by the Canadian Occupational Performance Measure (COPM) and Psychosocial Impact of Assistive Devices (PIADS) forms were completed, in addition to feature specific NASA-TLX forms. An Apple SE and Wahoo Tickr sports watches were used to record heart rat with Bland-Altman analysis carried out pre-trial. SPSS was used to carry out statistical analyses. The route pictured right was used with varying surfaces, cambers and features. Any unpredictable features (cars/ pedestrians) were noted down during the route.



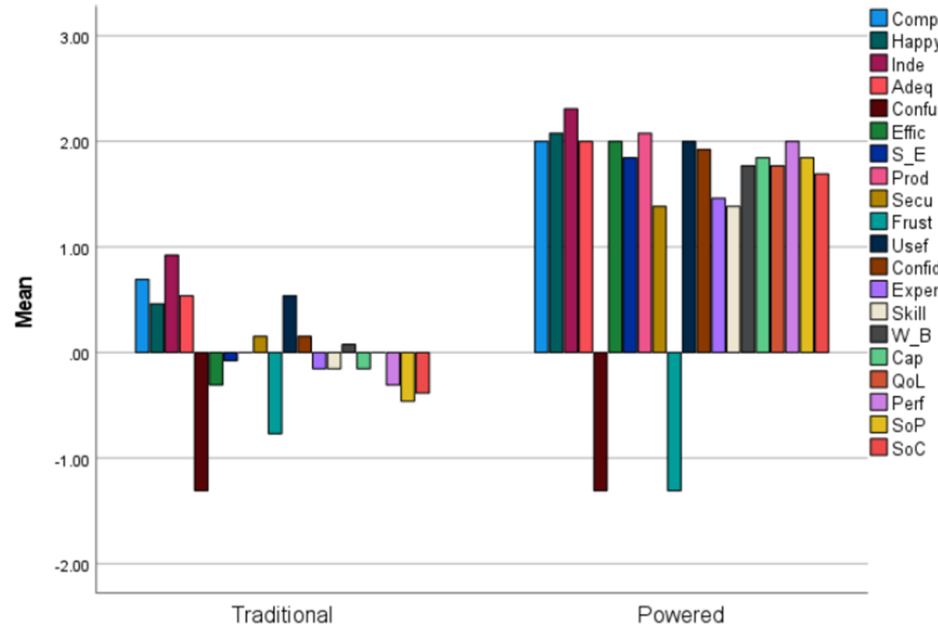
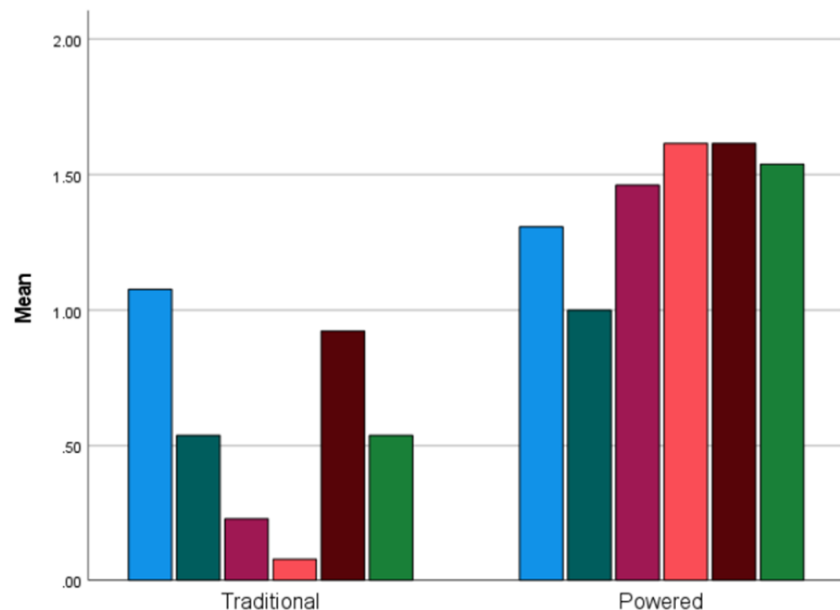
FINDINGS

The Wilcoxon Signed Rank Test indicates that the PAPAWs (median = 17:39) were statistically significantly faster than the traditional wheels (median = 26:47), $Z = 37.163$, $p < .001$. This is a reduction of 9 minutes 8 seconds when the PAPAWs were used, or that the powered wheels are approximately 34.1% quicker in the group (34.101% when comparing the median times). Only one person saw an increase in time in the PAPAWs, and did complete using these first which may explain this anomaly.



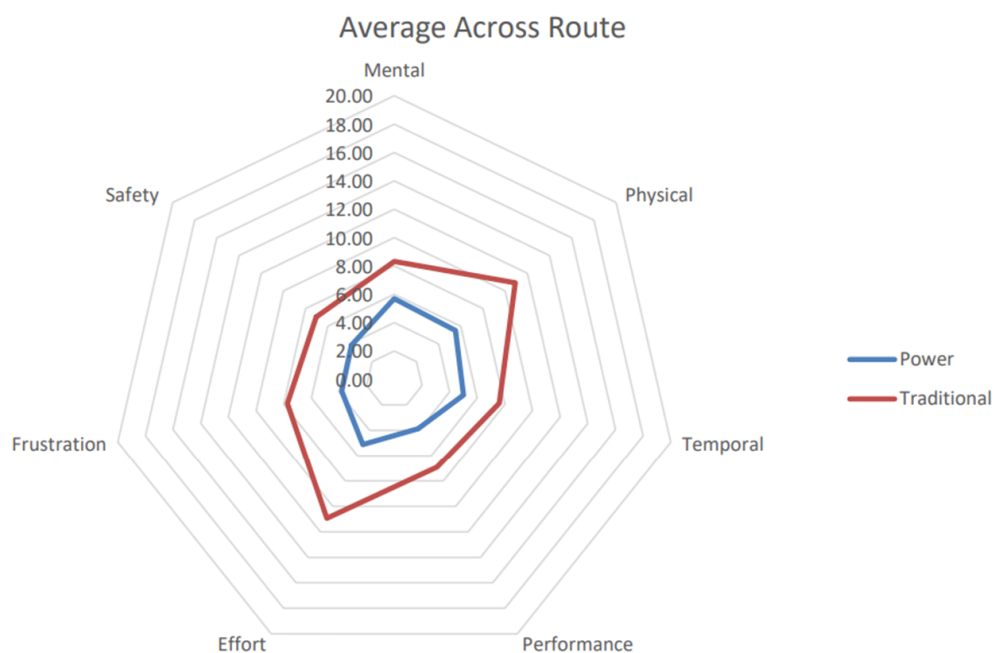
Average heart rate (bpm) in a paired t-test indicates that PAPAWs (mean = 105.32) were statistically significantly lower than traditional wheels (mean = 112.7), $p < .010$. Maximum heart rate (bpm) in a paired t-test also indicates that PAPAWs (mean = 123.3) were statistically significantly lower than traditional wheels (mean = 134.63), $p < .003$. Total push count in a paired t-test indicates that PAPAWs (mean = 800.08) were statistically significantly lower than traditional wheels (mean = 1049.92), $p < .009$. Total push count in a paired t-test indicates that PAPAWs (mean = 800.08) were statistically significantly lower than traditional wheels (mean = 1049.92), $p < .009$.

FINDINGS



For 24 out of the 26 metrics, the participants ranked the PAPAWs as more positive than the traditional, with the exceptions of Confusion and Frustration, the former rated identically and the latter being 0.54 lower than the traditional. Confusion and Frustration were also the two lowest rated metrics overall, which may be due to the lack of experience in wheelchairs meaning learning the techniques needed to navigate the outdoor environment were confusing and frustrating in themselves. Due to many participants not having experienced the outdoor built environment before in a wheelchair for many participants, there were frequent anecdotal verbal comments during the trial about features such as hills and kerbs that they would not even consider an obstacle while walking but found challenging in the wheelchair.

For the NASA-TLX ratings, Effort was hypothesised to have the largest improvement which see seen previously in the literature, Physical demand is the next highest improvement, which is closely linked to Effort in these trials where physical input is the main component required from the user to complete the task. Frustration, Safety and Performance are the mid-field of the scores and correlate to the more subjective feelings about completing the task. As individual scores across the two devices these metrics were also some of the lowest scores, indicating a good level of low frustration, good safety, and performance across the route. Comparing to the other scores, this may be that as they rely on other demands to complete the task, this allows their frustration, safety, and performance to remain low due to the increased mental and physical input.



DISCUSSION

Across all metrics, the PAPAWs displayed a statistically significant improvement and this could be expected to be seen clinically in a reduction in shoulder exertion and improved engagement in outdoor activities. Age had no significant impact on the results, but amount of exercise hours per week had a slight positive correlation with time taken that was statistically significant. It is recommended that PAPAWs be prescribed for patients who might struggle to cover typical walking distances or fin durban features challenging and a barrier to their activities of daily living. In additional feedback, there were 75% positive statements for the PAPAWs, against 23% positive comments about the traditional wheels. Typically mentioned in both a positive and negative light respectively is the effort and efficiency of the wheels, as hypothesised in this study based on the literature. Most values seen in the data are comparable with the literature, if slightly lower quantitative improvements than the laboratory based literature discoveries. PAPAWs required significantly less pushes to cover the same amount of distances that might reduce the risk of shoulder injury that can stem from repetitive exertion. Future work could do similar studies with the target patient population, typically adolescents and geriatric where muscle strength is less. Additionally, studies incorporating PAPAWs into a learning period of rehabilitation to maintain participation while the muscle bulk of the upper body and technique is improved.

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