

Wheels Project

Comparative Study of Curb Skills Performance for Self-propelling Users in Four Wheelchairs Designed for Low-resource Settings.

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Background

In low-resource settings, wheelchair users frequently encounter rough ground and obstacles similar to curbs. Therefore, wheelchairs designed to deal well with such obstacles are key to adequate mobility. Non-profit organizations providing wheelchairs for low-resource settings include Whirlwind (W-RR), Motivation (M-RT), Hope Haven (H-KC), and Free Wheelchair Mission (F-G2). Field studies are needed to confirm that designs are adequate for obstacles commonly encountered. A repeated measures skills study conducted in a low-resource setting over a track including curbs should be able to differentiate the ability of wheelchair types to provide adequate mobility over curb-like structures

Method

Participants were experienced wheelchair users who were students at our partner organization at a boarding school for children with disabilities. They were selected based on their ability to self-propel strongly on rough surfaces. Protocol was approved by all pertinent organizations and participants and their guardians completed assent and consent forms and were free to withdraw at any time. Each participant attempted to travel for 3 minutes in four types of wheelchairs made by W-RR, H-KC, F-G2, and M-RT over a track, which included two curb-like structures 9 cm high. The order of chairs was randomized and participants rested between tests. Heart rates and distance traveled were recorded and the physiological cost index (PCI) was calculated. Participants also provided feedback on each type of wheelchair through visual analogue scale questions.

Results

Disabilities of participants (n=30, 17M, 13F, mean age 13.55 SD3.42) included spina-bifida, amputations, spinal cord injuries, and cerebral palsy. The percentage of participants able to complete the test differed between wheelchair types as follows: 83.3% in M-RT, 76.7% in W-RR, 66.7% in F-G2 and 40% in H-KC. ANOVA analysis for distance traveled and participant feedback indicated wheelchair differed significantly in data from completed tests. The W-RR and M-RT outperformed F-G2 and all outperformed H-KC.

Discussion

It appears that a repeated measures skills test on a track with curb-like obstacles does differentiate the mobility provided by different types of wheelchairs. Energy cost and ease of movement over curb like obstacles is clearly impacted by design differences in wheelchairs. The exceptionally short wheelbase and anterior placement of the foot rest in the H-KC wheelchair seemed to be especially difficult because the curb could only be descended successfully in a wheelie, and the H-KC chair's anterior center of gravity made holding a wheelie difficult. In contrast the long wheelbase and more rearward center of gravity of the M-RT and W-RR chairs seemed to provide significant advantage. Wheelchair manufacturers have been provided with this data, and have expressed great interest indicating that results can be used for wheelchair modifications in the future.

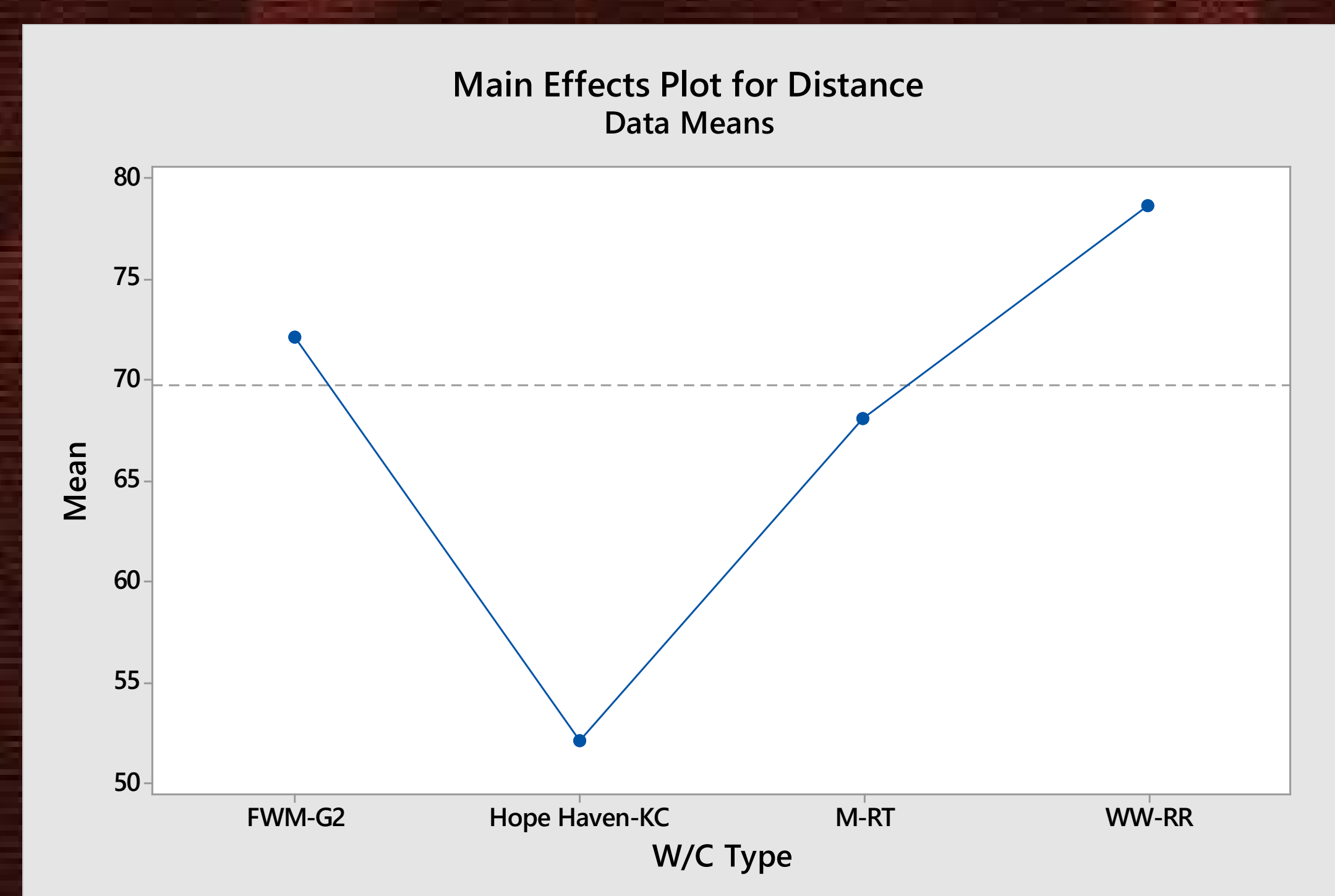
$$PCI = \frac{(Exercise\ Heart\ Rate) - (Resting\ Heart\ Rate)}{distance\ traveled(time)}$$

Figure 2. Equation to calculate Physiological Cost Index (PCI). Units are in heart beat per meter.

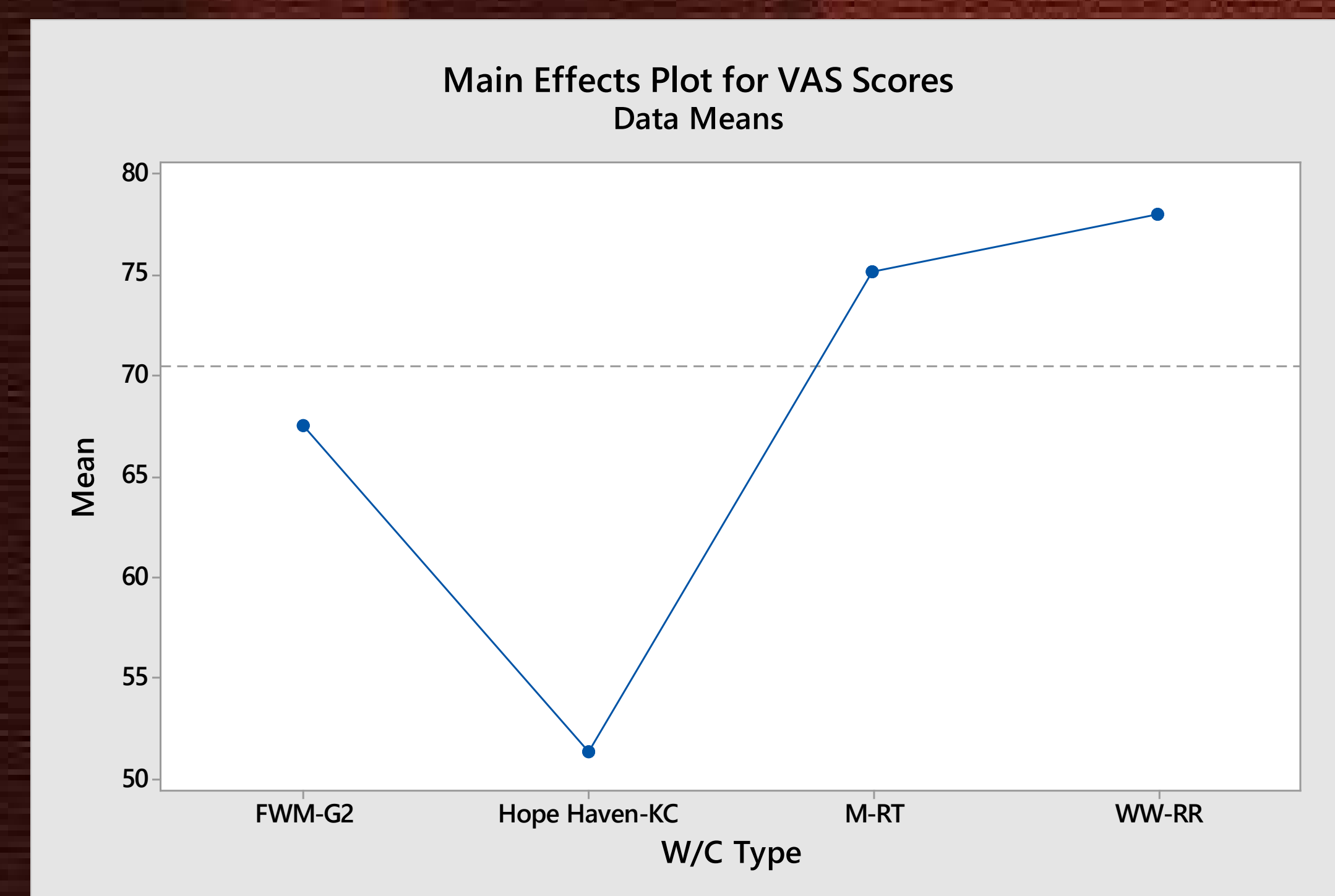
Metrics of The Four Study Wheelchairs	H-KC	W-RR	M-RT	F-G2
Wheel Diameter (cm)	57	61	66	65
Wheel Width (cm)	3.2	4.5	3.5	4.3
Castor Diameter (cm)	19	9.5	22	19
Castor Width (cm)	2.5	8	6	3.6
Wheel Base (cm)	32-27	51.8-59.8	75.1	44
Seat Width (cm)	35	39	42	45
Forward distance seat to foot plate (cm)	8 - 14	0 - 2	(-7) - 0	12.5 - 20.5
Verticle distance seat to foot plate (cm)	15.5 - 33.5	25 - 39	35 - 48	21 - 41
Height of top of seat above ground (cm)	48	50	55.5	54
Weight (kg)	23	19	22	24

Table 1. Above are the dimensions of the four study wheelchairs used in the curb study. The Hope Haven chair stands out in several categories including wheel diameter and height of top of seat above ground.

Figure 1. Curb study test being conducted in Kenya with a student from the school. Tests were conducted by a member of our team and a translator.



Graph 1. Graphical representation of distance travelled for the four study chairs.



Graph 2. Graphical representation of the VAS scores (Visual Analog Scale) for the four study chairs.



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