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Metabolic Cost of Ambulation by Visually Impaired Subjects Using Selected Mobility Aids: A Case Study.

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ABSTRACT:

Persons with visual impairments have two main options for independent mobility, a long white cane or a guide dog (GD). Previous research indicates this population has decreased physical activity across all age groups, correlating to higher prevalence of cardiovascular disease. Barriers to mobility, such as independent walking, have been demonstrated to be a significant secondary pathway to increased mortality among visually impaired persons over the age of 50. Few studies report on how either of these mobility aids affect the metabolic demand of ambulation and no research exists exploring the use or validity of a functional exertion test for individuals with visual impairment under usual mobility. The aim of this study was twofold: 1) to compare the metabolic demand of ambulation with a long white cane to that with a GD; and 2) to assess the use of the six-minute walk test in the visually impaired population.

INTRODUCTION:

Cardiovascular disease affects all genders and cultural groups and is the leading cause of death in the United States, with over 660,000 deaths annually.[1] Risk factors for acquiring heart disease include high blood pressure, high cholesterol, diabetes, depression, and obesity. Behavioral risk factors include smoking, a poor diet, not exercising and excessive alcohol consumption.[2]

Increasing physical activity is among the behavioral changes shown to mitigate the risk factors for cardiovascular disease.[2] Previous studies suggest that persons with visual impairment have decreased levels of physical activity across all age groups.[5,6,7] Decreased activity in persons with visual impairment are correlated to higher prevalence of cardiovascular disease.[9]

Additionally, impairments in walking are demonstrated to be a major indirect pathway to increased mortality among visually impaired persons over the age of 50.[8]

While low levels of activity are due to multiple factors, one key factor for this population is the barrier to ambulation. The primary choices of mobility aids, a long white cane or a guide dog, have been shown to improve activity levels and decrease fall risk. Additionally, some studies suggest that utilizing a guide dog may increase a person's physical activity compared to long cane use.[9] While there is available research on physical activity levels among persons with visual impairment,[3] there is a paucity of research data on how each mobility aid affects this population's independence. There is no research investigating metabolic demands of using mobility aids or validation of functional gait measures like the six-minute walk test (6-MWT)[7] for this population.[7,10] The 6-MWT may be a useful screening tool in determining functional capacity and its relationship to cardiovascular health in persons with visual impairment and provide a screening tool for healthcare providers working with this population.

This pilot study investigated the metabolic demands of ambulation using a long cane and guide dog for persons with visual impairment. The aim of this investigation was to determine potential impact of mobility aid choice on metabolic demand and to assess the use of the 6-MWT for persons with visual impairment. We hypothesize that the use of a guide dog would be a more efficient means of independent mobility, requiring a lower metabolic cost compared to long cane use for persons with visual impairment.

METHODS:

Subjects were recruited from a convenience sample of a support group for persons with visual impairments from the North Georgia area. At the time of this pilot study, two subjects

were recruited and qualified (1 male, 1 female). Exclusion criteria included (a) current musculoskeletal injuries, (b) history of cardiopulmonary disease, and (c) tobacco/recreational drug use. Inclusion criteria consisted of (a) persons with visual impairment defined as legally blind, (b) 18 years or old, (c) had transportation to the facility for testing, and (d) were proficient at using both a long cane and a guide dog. This study describes the results of the first two trials in a case study designed to test our hypothesis. Approval for this study was granted by the IRB of UNG.

A pre-screening questionnaire was administered to each subject prior to testing. The questionnaire captured demographic information about (a) each participant's history of visual impairment, (b) long cane and guide dog use, (c) whether they have any pre-existing conditions (especially cardiopulmonary), and (d) description of usual physical activity level. After the questionnaire, resting blood pressure and body weight were recorded. The Semmes Weinstein monofilament test was used to screen for sensory deficits to eliminate confounding factors that might affect gait and balance.

Participants then completed a 6-MWT with each mobility aid. Participants utilized their long cane first. The test was administered in a 150-foot walkway with a cone at each end to mark where participants needed to turn around. Researchers were positioned on each end to verbally confirm when the participant was getting close to the cone for safe transitions. Participants walked as quickly and safely as possible for the full duration of 6 minutes. The total distance covered was recorded after each test to the nearest tenth of a meter. Metabolic data were collected throughout the test using the K4 Portable Metabolic System (CosMed).[11] Each participant was fitted with a facemask to collect expired air and a chest harness to carry the small

device and battery pack. The main variables recorded by the K-4 system included minute ventilation (VE; ml/min) and oxygen consumption (VO2; ml/min/kg).

Heart rate (HR) was measured using a Polar HR monitor chest strap. BP was recorded manually immediately before and immediately after each 6-MWT. Rate of perceived exertion was collected using the Borg Scale (6-20) before and after each test. A 30-minute rest break was allowed between tests to ensure return to the resting state, after which the same procedures were followed when testing with the guide dog.

Data were processed using Excel and stored securely between collection sessions. Data analysis utilized results from the 6-minute walk test distance, Rate of Perceived Exertion, and data gathered from the K4 Portable metabolic device. The main variable of interest was O2 Cost of walking.[12] This measure is derived by dividing O2 consumption or VO2 by the average walking speed in m/min. This measure was used in a similar study[12] where O2 cost in sighted persons with knee osteoarthritis was compared with and without use of a mobility aid. Linear regression was performed on O2 cost for each condition to help visualize and contrast the data from both the cane and dog-walking trials. Due to the small sample size, no statistical comparisons were performed for within or between subject comparisons.

RESULTS:

Participant 1 had a higher 6-MWT distance when using his guide dog. He walked 342.8m with the long cane and 382.1m when utilizing his guide dog. His RPE demonstrated consistent perceived effort for both trials. Participant 1 had slight numerical differences between VE and VO2 at the beginning of the two walking trials. This variability may be reduced by using a longer rest period for future collections. The mean O2 cost per meter of walking with a dog was

numerically only slightly lower than walking with a cane during the 6-MWT. Participant 1 had a O2 cost of 0.2 ml/kg/m with the cane and 0.18 ml/kg/m with the dog (Table 1).

In contrast to participant 1, participant 2 walked further in the 6-MWT when using her long cane. She walked 351.2m with the long cane and 329.2m when walking with her guide dog. The Borg RPE demonstrated similar perceived effort during each walking condition. Participant 2 also had a slightly increased VE and VO2 at the start of the second trial which again suggests that longer rest periods between trials may be necessary. The average O2 cost of walking was 0.25 ml/kg/m with the cane and 0.27 ml/kg/m with the guide dog. Participant 2 demonstrated a mean O2 cost per meter that was numerically lower when walking with the cane. This is also contrary to Participant 1 who had a lower O2 cost with his guide dog (Table 2).

Linear regression was performed to visualize O2 Cost of each condition for both participants. (Figure 1). Participant one's O2 Cost increased throughout the test in both conditions but more so in the cane. Participant two's O2 Cost remained relatively unchanged during the duration of the test but remained higher throughout when walking with the dog.

DISCUSSION:

This preliminary case series was designed to observe differing metabolic patterns in 2 subjects who are visually impared during a 6-MWT. Due to the limited sample size, no statistical analyses were performed. Minor differences were observed in the O2 cost of walking and total distance covered within each subject according to the mobility aid being tested. We hypothesized that the mobility aid that corresponded to the lower O2 cost of walking would lead to a longer ambulatory distance covered in the allotted 6 minutes. From an observational perspective, this appears to be the case for both participants.

While the experimental design attempted to control for extraneous variables, multiple confounding factors existed that could have led to the differences within participants observed data. The number of years of visual impairment, percentage of visual field loss, natural walking pace, age, and baseline physical fitness levels are examples of individual factors that vary between participants. Other contributing factors include the selected mobility aid itself; while the cane is an inert aid that is under complete control of the user, each guide dog presents with a unique behavior pattern, walking pace, fitness level, and training history. While other factors can be better controlled in future studies involving the measure of cardiovascular and metabolic demand on the visually impaired, controlling for physical and behavioral differences between guide dogs may need to be examined independently.

This study provides potential experimental design procedures and data collection strategies that establish a foundation for future studies to address the cardiovascular health in this underserved population of persons with visual impairments. Barriers to independent mobility decrease access to exercise and make it difficult to achieve optimal cardiovascular health. The use of both the long cane and guide dog as a mobility aid to eliminate the barrier to exercise is poorly studied. This study introduces the 6-MWT as a potential clinical assessment for visually impaired conditioning. A larger sample size is needed to better examine the metabolic cost of various mobility aids in the visually impaired community. Future studies are needed to provide researchers and healthcare professionals with data to support appropriate, personalized mobility aid prescription for this population.

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Table 1. 6-MWT, RPE, and K4 results for participant 1

Participant 1	Cane (mean)	Dog (mean)	Difference
Distance (m)	342.8	382.1	+39.3
Initial BORG RPE	6	7	+1
Final BORG RPE	11	10	-1
Initial VE (ml/min)	16.99	22.45	+5.46
Final VE (ml/min)	26.82	28.33	+1.51
Initial VO_2/kg (ml/kg/min)	6.82	10.32	+3.49
Final VO_2/kg (ml/kg/min)	12.73	12.23	-0.51
O_2 cost of walking (ml/kg/m)	0.20	0.18	-0.03

Table 2. 6-MWT, RPE, and K4 results for participant 2

Participant 2	Cane (mean)	Dog (mean)	Difference
Distance (m)	351.2	329.2	-22
Initial BORG RPE	7	7	0
Final BORG RPE	13	14	+1
Initial VE (ml/min)	29.08	35.26	+6.18
Final VE (ml/min)	39.42	40.94	+1.53
Initial VO_2/kg (ml/kg/min)	12.08	14.61	+2.53
Final VO_2/kg (ml/kg/min)	14.42	15.35	+0.93
O_2 cost of walking (ml/kg/m)	0.25	0.27	+0.02

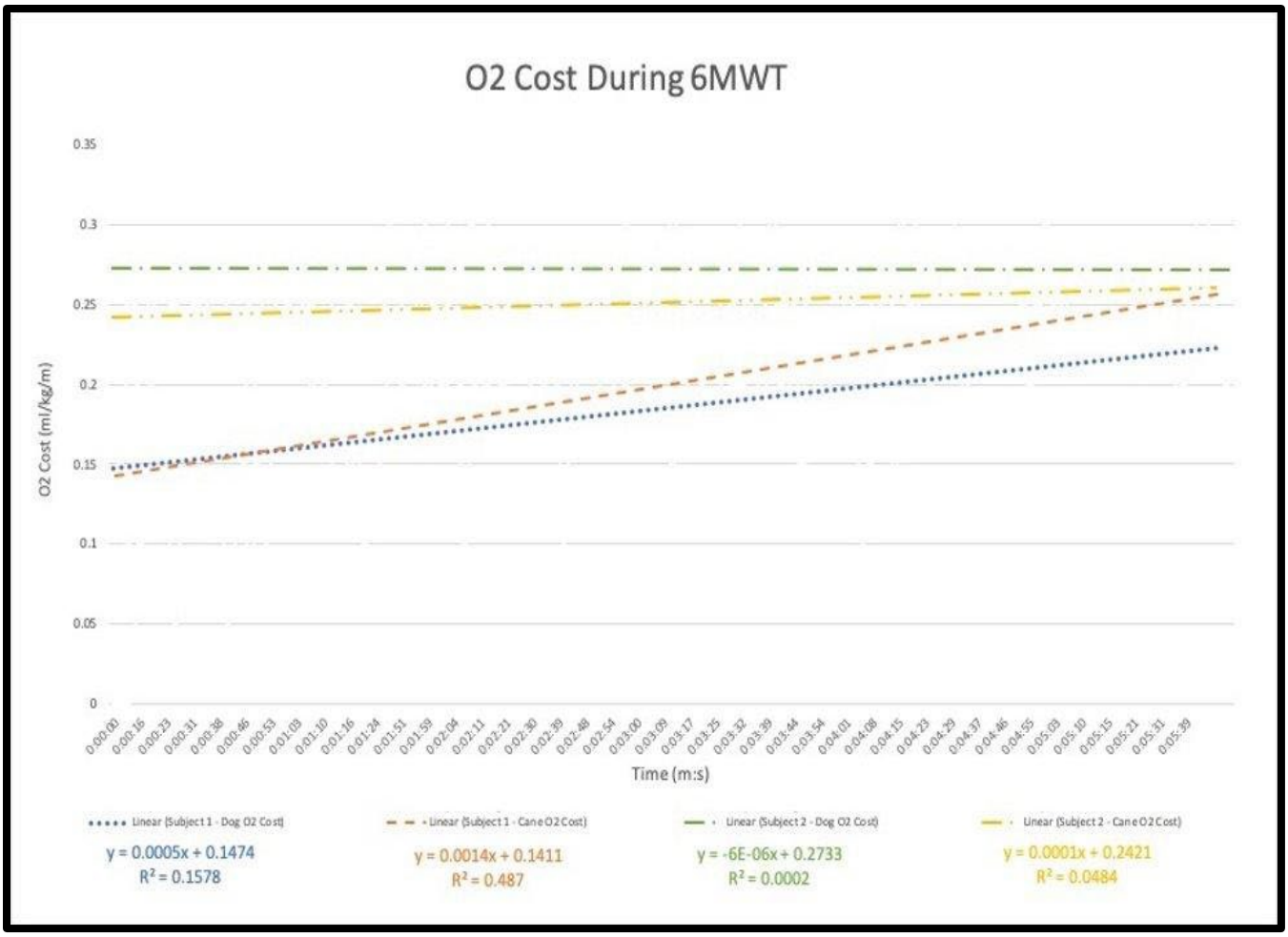

Figure 1. The linear data for participant one is blue for the guide dog trial and orange for the long cane trial. The linear data for participant 2 is green for the guide dog trial and yellow for the long cane trial.

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