Targets:

Improved Design of Mobility Devices

Team 526

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1.0 Functional Decomposition

The functional decomposition originally submitted for the assignment was revised and changed and included in our VDR1. This newly revised functional decomposition can be seen below for better visualization and comparison:

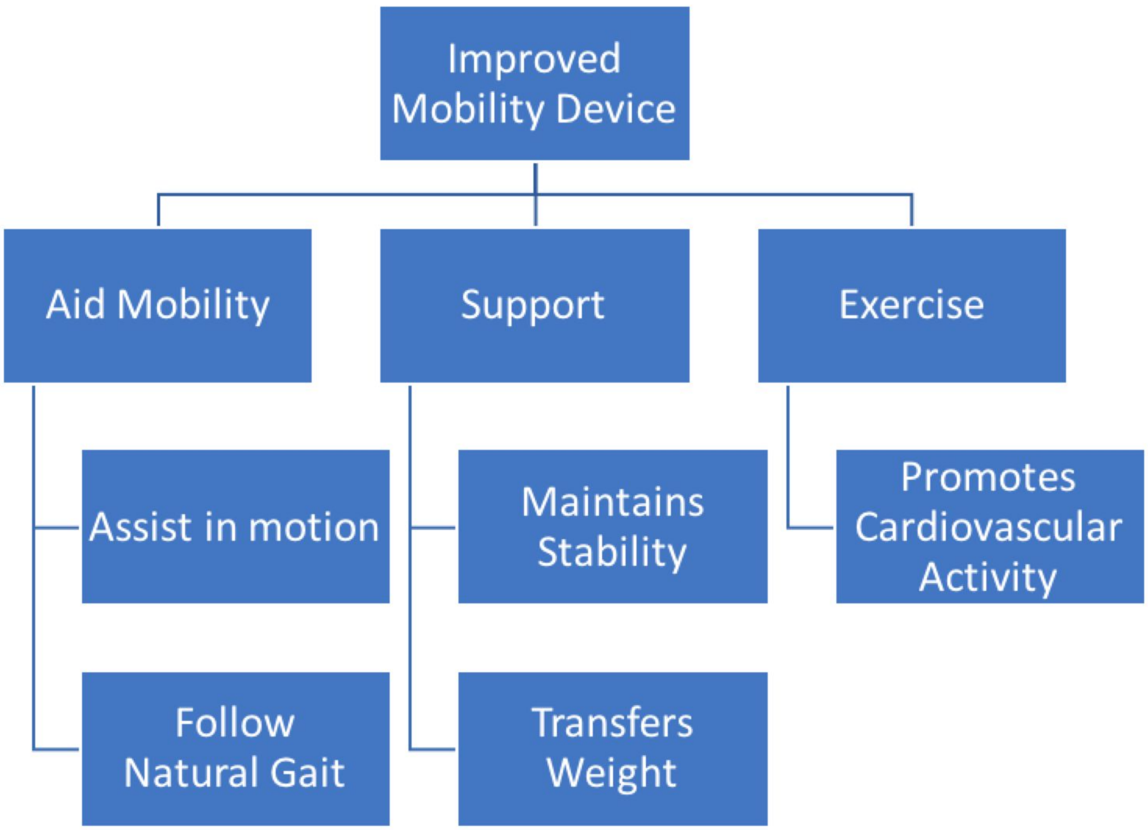

Figure 1: Functional Decomposition block diagram

2.0 Targets and Metrics

2.1 Aid Mobility

In order to aid the users mobility, our target is to increase the walking efficiency of the user. This can quantified using the following equation:

$$efficiency = \frac{work\ output}{work\ input} * 100\%$$

Looking at the efficiency of the user without the help of the device and comparing it to the efficiency of them walking with it, our goal is to increase the overall efficiency by 15%. By increasing the overall efficiency, it in turn means that the device lowers the user's weight and helps aid their mobility.

2.2 Assist in Motion

This device will be expected to improve the users' walking ability. To demonstrate this improvement, gait parameters will be taken with and without the use of the device. These gait parameters will be gait speed and stride consistency. The improvement in walking ability will be quantified through the comparison of these two parameters, with and without the use of the device.

2.3 Follow Natural Gait

To ensure that the device does not affect the natural walking pattern of a user, gait measurements will be taken from a 20 foot walk with and without the use of the device. These two sets of gait measurements will be compared to quantify any change in gait that the device could have caused. These gait measurements will include average stride length (meters), average step width (meters), and average step frequency (steps/second).

2.4 Support

According to *The Third National Health and Nutrition Examination Survey* (NHANES III), the 95th percentile male is 246 lbs (111.58 kg). To target as many consumers possible, the device will be designed to accommodate users up to 250 lbs.

2.5 Maintains Stability

According to an article published by PLoS One, *Dynamic Parameters of Balance which Correlate to Elderly Persons with a History of Falls* (Muir), research was done tracking the center of pressure of healthy young adults and elderly adults with a history of falls, while quietly standing still over a period of 4 minutes. The results of this study showed that the variation in center of pressure (COP), or "postural sway" of the younger adults was much less than that of the elderly adults who had a history of falls. This suggest that the variation in COP is a good indication of stability. To quantify the improved stability that our device will provide, the COP will be recorded over a period of 4 minutes with the use of our device and without the use our device.

2.6 Transfers Weight

In order to aid the user of this device in mobility, some of their weight will be transferred from the ground to them. The different types of weight transfer have been broken down into upper body and lower body weight transfer.

Upper Body Weight Transfer: Studies done by, Clinical Interventions in Aging (Ko), have suggested that having the elbow at a 90 degree angle is more suitable for reducing the lower extremity load during weight bearing. While walking with the elbow at a 130 angle is more suitable for mobility. These optimal angles will be the goal for any upper body weight transfer.

Lower Body Weight Transfer: The paper, *Body size and lower limb posture during walking in humans* (Hora), presents data collected from 24 females and 25 males about their lower limb posture while walking. The average hip, knee, and ankle change in angle while walking were all said to be 8 degrees. Therefore our device will be designed to allow the user at least an 8 degree variation in angle of their hip, knee, and ankle while using it to walk.

2.7 Exercise

Prolonging the well-being of the user through the means of physical health helps with longevity of their joints and cardiovascular system. By requiring a physical input from a user our device will promote cardiovascular activity. This target will be met by measuring the resting heart of an individual, and the heart of the same individual while using the device. By comparing these and showing an increased heart rate from resting, we will be sure that our device is requiring physical input from the user.

2.8 Promotes Cardiovascular Activity

Promoting the physical health of the individual will be done with having the device require a physical input prompting cardiovascular exercise. Cardiovascular activity is anything that increases the heart rate of an individual. To meet this target, resting heart rate readings will be taken and compared to heart rates after using the device for a given time.

2.9 Affordable Price

The prices of the first 20, 4 star or above, standard walkers found on Amazon.com were averaged to determine the average price at which competitor products are currently being sold at. The average cost of a standard walker, calculated from the Amazon.com search, was found to be roughly $90. Additionally, similar products already on the market were researched online. A product called the UPWalker was found to share the most similarity with what is understood to be the goal of our device. This device, priced much higher than basic walkers, had a base price of $595.

2.10 Dimensions

An important feature that an assistive mobility device must have is that it is of reasonable dimensions to suit consumers. One key feature is that the device can fit through standard doorways. According to the 2017 Florida Building Code, the standard door clearance required in Florida is a minimum of 32 inches. Another key feature is that the device will be able to accomodate the average sized adult male and female. According to the National Center for Health Statistics, the average height of an adult male is 69.2 inches while the average height of an adult female is 63.7 inches. Also, the average waist circumference of adult males is 40 inches and for adult females is 38.1 inches.

3.0 Critical Functions

The functions that we found to be most critical include Aid Mobility, Support, and Promotes Cardiovascular Activity.

3.1 Aid Mobility

- **Method of Validation**

  To calculate the increased walking efficiency, one has to find the work fraction being done by the device while a user is walking. The work done without the device can be calculated by the user standing on a scale (thus obtaining the users weight), multiplied by the force of gravity ($\frac{m}{s^2}$) and the distance the user walks. This distance can be any arbitrary length if kept consistent with calculating the work done by the device. The work done by the device can be calculated similarly, except by using the fraction of weight the device is taking off the users feet. The ratio between the work done by the device to the work done without the device is the percentage increase in walking efficiency.
- **Derivation**

  These targets of increasing efficiency by 15% was derived by the team members estimation of the ability of the device to take off 15% of the user's weight once using the device.
- **Measurements**

  The user's weight can be measured by a scale obtained from a team members household and the distance walked can be found using a yardstick.

3.2 Support

- **Method of Validation**

  To determine how much weight the device can withstand, various increments of weight will be added to the top of it. Weights will be continuously added until the desired weight that the device is required to hold is met.
- **Derivation**

  The device must withstand the maximum percentage of the users total weight up to a maximum total weight of 250 lbs. This value was used because it is a little bit over the 95th percentile male weight which was derived from the NHANES III survey.
- **Measurements**

  Measurements will be obtained using dumbbells.

3.3 Promotes Cardiovascular Activity

- **Method of Validation**

  To measure the heart rate in beats per minute the user will start a stopwatch and begin walking with the device. The user will measure their heart rate on their neck. They will measure how many beats they feel for 6 seconds. This number obtained will be multiplied by 10 to determine their bpm.
- **Derivation**

  The use of the device must result in the user increasing their heart rate from their resting heart rate.
- **Measurements**

  The heart rate of the individual can be measured by checking the users pulse and a stopwatch to measure time differences.

4.0 Target Catalog

Function	Metric	Target	Units
Aid mobility	Walking Efficiency	15% Improvement	Percent Improved Efficiency (%)
Assist in Motion	Walking Improvement	Increased speed and stride consistency	Percent Improved speed and Consistency(%)
Follow Natural Gait	Varied gait	Minimal gait variance	Percent variation in gait (%)
Support	Weight	250	lbs
Maintains Stability	Center of Pressure (COP)	Decreased Variation of COP	Percent Variation (%)
Transfers Weight	Weight Transfer Angles	Optimal Transfer Angles	Degree (°)
Exercise	Heart Rate	Increased Heart rate	Beats per minute (bpm)
Promotes Cardiovascular Activity	Heart rate	Increased Heart rate	Beats per minute (bpm)
Affordable Price	Competitor Prices	\$90 (Max of \$595)	US Dollars (\$)
Dimensions	Standard Door Width, Average Male/Female Body Dimensions	Width << 32'' 30'' < Height < 40'' 35'' < Circ. < 40''	Inches (in)

5.0 References

1. Hora, M., Soumar, L., Pontzer, H., & Sládek, V. (2017). Body size and lower limb posture during walking in humans. *PLoS ONE*, *12*(2), e0172112. http://doi.org/10.1371/journal.pone.0172112
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3. Muir, J. W., Kiel, D. P., Hannan, M., Magaziner, J., & Rubin, C. T. (2013). Dynamic Parameters of Balance Which Correlate to Elderly Persons with a History of Falls. *PLoS ONE*, *8*(8), e70566. http://doi.org/10.1371/journal.pone.0070566
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