Abstract:

From the months of September 2021 through December 2021, LiveWell and its team members collected participant data regarding force and power output and measurements relating to balance. The participants ranged from 57 to 98 years of age, residing within Independent or Assisted living communities throughout southwest Florida. The average age for the participants was 85 years of age, while the median was 86 years of age. Prior to participation in the exercise movements, participants were asked how many of the five activities of daily living they were able to complete independently (bathing, dressing, transferring, toileting & eating). Participants also provided information regarding their functional ability regarding stair climbing and assistive device use. Participants were asked to perform three squats coinciding with the data collector’s direction (Andrew Sokolowski), squat force and squat power was collected after interpretation of the best squat performed based on output numbers. The average remained at 779 Newtons of Force (median= 788), while the power remained at 267 Watts (median = 242). Participants were also asked to perform one quiet stand balance (following a practice) with eyes closed in which area of ellipse was measure utilizing VALD Force Plates. The average calculated ellipse was 100 mm2 (median= 55 mm2).

Introduction:

Muscle strength, more specifically muscle strength within the geriatric population is challenging to accurately test, due to the risk involved when completing various testing procedures. Many of the reasons for reduction in strength have been reviewed, much of the evidence points towards a loss of muscle mass. Though true, there is also evidence that suggests the force -producing capacity of muscles occurs at an earlier and a faster rate than reductions in muscle mass (Macaluso and De Vito, 2004). As atrophy continues to be a leading factor in an aging individuals’ decline in health it has become more apparent that testing muscle strength should be done with individuals regardless of age. With that said, traditional strength testing for the elderly may be deemed ineffective because of its poor application to various subgroups for those over the age of 65. The lack of data regarding strength in this area means that a maximal strength testing does very little to nothing when we are attempting to compare an individual to their age matched counterparts or those with the same functional ability. A squat of 95 pounds for a gentleman approaching 80 years of age is surely impressive but regarding the greater picture and understanding where that individual remains regarding others in his situation remains to be unknown with traditional strength testing. With that said, it should also be noted that without an extensive lab with various providers, equipment and funding, accurate and detailed strength testing among geriatric populations is very challenging.

Our goal was to find a strength testing protocol that allowed us to understand more than simple one-repetition-maximums or predicted ten-repetitions-maximums. The deep dive allowed for more information the be gathered which could then be compared with age and functional ability counterparts, thus creating a spectrum in which individuals would find themselves. This would help determine an exercise program, as well as be a predictor of where they might be heading (i.e. next level of care – AL, SNF, etc.)

The Force-Power relationship has become one of the most effective predictors of functional outcomes in older adults. The neuromuscular system has a major influence on functional ability throughout the aging process (Aagaard et al., 2010) and impaired muscle power should be considered one of the most important outcomes associated with functional limitations and disability in older adults (Byrne et al., 2016). Colleagues Izquierdo & Cadore (2014) and Reid & Fielding (2012) also stated muscle power should be recognized as a significant and strong predictor of functional ability in older people as well as its critical influence on remaining independent in later life.

Force and power output often require an extensive lab that many practioners have very little to no access. Fortunately, with the use of VALD Heath’s Force Plate Mini we (LiveWell Health) were able to detect these exact metrics in order to have an understanding of the wellness landscape of individuals residing within independent and assisted living communities throughout southwest Florida.

Methods

Various senior living facilities were contacted at random to understand their willingness and interest to participate in this study. While some saw it is as an interesting opportunity for the residents, others were turned away by the limited understanding of the technology and our goals as an organization. In total, 115 (61 assisted living residents, 54 independent living residents) various participants were screened over a period of four months.

Prior to residents initiating testing they were asked to complete a self-guided questionnaire in which they indicated their age, ADL ability, functional ability regarding stair climbing and if they used an assistive device to ambulate. Participants were unable to participate in the study if they did not have the ability to stand with the use of a walker.

Participants were then each given the same directions with each squat test as well as quiet stand balance test. Participants were given three squat opportunities and one balance test opportunity. The best result for squat and balance was noted. Participants were not given additional attempts.

Data was gathered and subdivided into various categories:

* Independent vs. Assisted Living
* Ability to Stair Climb Independently vs. Requires Assistance
* Uses and Assistive Device vs. Ambulates Independently
* Age (70-79, 80-89 & 90-99)

Force, power, and balance metrics were compared among each various groups with the intention of creating normative values as well as a guide to understand where individuals stood regarding their counterparts.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| IL Residents  | AL Residents  | Male  | Female | Stair Climbers  | Non- Stair Climbers  | AD Users  | Non AD Users  | 70-79 Years Old  | 80-89 Years Old  | 90-99 Years Old |
| 54 | 61 | 34 | 81 | 79 | 36 | 65 | 50 | 16 | 59 | 34 |

**Data**

When comparing data across the entire subset our main goal was to begin understanding where comparative norms may fall. Each data collection was conducted within independent and assisted living communities, therefore understanding the normative value for those within various communities can potentially set thresholds for those who wish to age in place.

Across the participation spectrum we were able to breakdown the data into various cohorts including comparisons between age matched individuals, those within assisted living and independent living, those who can and cannot climb stairs and those who utilize an assistive device and those who do not.

1a.

|  |  |  |
| --- | --- | --- |
| Average Force  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| 779.96 N  | 60  | 52%  |

|  |  |  |
| --- | --- | --- |
| Median Force | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| 788 N  | 56 | 49%  |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 10th  | 20th  | 30th  | 40th  | 50th  | 60th  | 70th  | 80th  | 90th  | 99th |
| 545.8 | 634.4 | 691.6 | 751 | 788 | 833.2 | 895.8 | 974 | 1071.2 | 1277.4  |

1b.

|  |  |  |
| --- | --- | --- |
| Average Power | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| 267 W  | 51 | 44% |

|  |  |  |
| --- | --- | --- |
| Median Power | Number of Participants Who Outperform the Median  | Percentage of Participants Who Outperform the Median |
| 242 W  | 56 | 49% |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 10th  | 20th  | 30th  | 40th  | 50th  | 60th  | 70th  | 80th  | 90th  | 99th |
| 123.4  | 154.2  | 186.2  | 211.8 | 242 | 275.8 | 304.8 | 351.6 | 466 | 723.08  |

1c.

|  |  |  |
| --- | --- | --- |
| Average Area of Ellipse  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| 299 mm Sq  | 100 | 87%  |

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| --- | --- | --- |
| Median Area of Ellipse  | Number of Participants Who Outperform the Median  | Percentage of Participants Who Outperform the Median |
| 89 mm Sq  | 55 | 48% |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 10th  | 20th  | 30th  | 40th  | 50th  | 60th  | 70th  | 80th  | 90th  | 99th |
| 274 | 197.8 | 163.3 | 112.2 | 89 | 71.4 | 55 | 45.8 | 34 | 14.36 |

Of the 115 participants, 34 (30%) were male and 81 (70%) were female. Prior to data collection it was expected that men would produce greater rates of force and power, whereas balance would show little variance between man and woman.

After calculating for various confidence intervals within the gender cohort, it can be said with greater than 99% confidence that males (p value = .000042) and females (p value = .0041) will score within the force production ranges shown in figure 2a. The data clearly demonstrates a relationship between force output and the variance that occurs between males and females. That said, there is a variance between male and female relating to force production. Males outperformed females by 19 and 18% (average and median).

2a.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average Force  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| Male  | **890 N** | 18 | 53%  |
| Female | **722.96 N**  | 42 | 53% |

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| --- | --- | --- | --- |
|  | Median Force | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| Male  | **900 N**  | 16 | 47% |
| Female | **742 N**  | 39 | 49% |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| Male  | 720.6 | 794.4  | 832.2  | 873.6 | 900 | 960.2 | 983 | 1058.8  | 1107.2 | 1170.6 |
| Female | 513.2  | 606.2  | 663.4  | 697 | 742  | 781.8 | 819.6  | 881.2  | 1017.4  | 1173.56  |

When comparing the variance between male and female regarding power production it was found the male power ranges would accurately depict an entire population with 99% confidence (p value = .01). However, the female population did not elicit statistically significant results (p value = .07). A difference is shown (Figure 2b) relating to male and female power production as male produce force at rates 30% greater than females, but with a p value greater than 0.05 we cannot confirm this data accurately depicts an entire population. More data will be needed to further evaluate the relationship between male and female power production.

2b.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average Power  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| Male | **327 W** | 14 | 41% |
| Female | **231 W**  | 35 | 44% |

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| --- | --- | --- | --- |
|  | Median Power  | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| Male  | **303 W**  | 16 | 47% |
| Female | **213 W**  | 39 | 49% |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| Male  | 189.8 | 215.6 | 253.2  | 285.2  | 303 | 339.4 | 360.8 | 459.6 | 505 | 638.12 |
| Female | 120.8 | 131.6  | 158 | 191.4 | 213 | 247.6 | 269 | 313.8 | 374 | 665.48 |

The figure below shows males outperformed women (a smaller area of ellipse depicts greater balance) at a rate of 16% (average) and -23% (median). After calculating for statistical significance we found that the data did not accurate represent an entire population with p values of .45 (male) and .82 (female).

2c.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average Area of Ellipse  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| Male  | **265 mm Sq**  | 22 | 65%  |
| Female | **314.82** | 75 | 95% |

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| --- | --- | --- | --- |
|  | Median Area of Ellipse  | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| Male  | **98.5 mm Sq**  | 16 | 47% |
| Female | **76 mm Sq**  | 37 | 47% |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| Male  | 671.4  | 394.6 | 253.9 | 115.4 | 98.5 | 88.8 | 83 | 56.8 | 46 | 24.34 |
| Female | 229.8 | 174.6 | 128 | 99.8 | 76 | 65.4 | 50.8 | 41.6 | 33 | 12.8  |

Of the 115 participants in the study, 54 (47%) of the participants reside within independent living (IL) while the remaining 61 (53%) of participants reside within assisted living (AL). Many individuals move from independent living to assisted living due to a decline in health. It is expected that force, power, and balance would decline as one resides within assisted living.

Separating the entire participatory group into cohorts of living, IL and AL was of grave importance as we hope to understand and develop a threshold that may occur as one moves from IL to AL. When calculating for statical significance regarding force production we can state with greater than a 95% confidence the data shown in figure 3a. is an accurate depiction of entire populations within IL (p value .012) and AL (p value .0002) communities. A small amount of variance occurs when comparing the average and median (less than 5%), however standard deviation shows considerable variance (22%) relating to the lower ranges of IL (583 N) and AL (459 N) residents.

3a.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average Force  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| IL  | **797.78 N** | 28 | 52% |
| AL | **763.66** | 33 | 54% |

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| --- | --- | --- | --- |
|  | Median Force  | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| IL | **802 N**  | 27 | 50%  |
| AL | **785 N**  | 29 | 48% |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| IL  | 573 | 664.6 | 707.4 | 757.6 | 802 | 833.8 | 866.9 | 942 | 1089.8 | 1234.35 |
| AL | 521 | 631.6 | 668.4  | 734.2  | 785 | 821.8 | 913.6 | 983 | 1052 | 1355.78  |

Males outperformed females regarding power production by 25% (figure 3b) relating to the average and the median, however after calculating for statical significance it was found that the IL residents accurately depicted what a population would show (p value= .04), the AL residents did not (p value .14), therefore we cannot state with complete certainty that this is how power production would occur in the real world. Taking standard deviation into consideration we note that the lower range for IL residents remains at 156 W, while AL residents remain at 74 W, which represents a 53% difference, and the potential for a threshold to be determined when assessing IL and AL residents.

3b.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average Power  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| IL | **307 W** | 23 | 43% |
| AL | **230.22 W**  | 22 | 36% |

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| --- | --- | --- | --- |
|  | Median Power  | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| IL  | **280.5 W**  | 27 | 50% |
| AL | **210 W** | 29 | 48% |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| IL | 132.2 | 181.2 | 214.7 | 269 | 280.5 | 314.6 | 344.1 | 438.6 | 498.4 | 696.02 |
| AL | 108.2  | 134.4  | 158.8 | 193.8 | 210 | 227.8 | 265.4 | 303.4 | 366.8 | 732.4  |

Vast difference was observed when calculating the average and the median balance metric (area of ellipse in mm Sq). The median appears to show a more accurate representation of the data, as 84% of individuals within AL outperformed the average. When comparing the median of IL and AL residents the data illustrates that IL residents outperformed the AL residents by 19%. However, the data does not represent an accurate representation of normative populations as p value= .48 (IL) and p value = .78 (AL) are not within the set standards of this study.

3c.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average Area of Ellipse  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| IL  | **124 mm Sq**  | 35 | 65%  |
| AL | **462.15 mm Sq** | 51 | 84% |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Median Area of Ellipse  | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| IL | **76 mm Sq**  | 25 | 46% |
| AL | **93 mm Sq** | 28 | 48% |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| IL | 232.6 | 172.6 | 134.4  | 95.6 | 76 | 64 | 50.6 | 41.4 | 32.2 | 11.6 |
| AL | 456 | 234.4  | 180.4 | 124 | 93 | 83 | 64 | 48 | 40.6 | 22.48 |

Use of an assistive device is often viewed as a balance deficiency, however the calculations and data in the figure below (4a, 4b, 4c) illustrate that use of an assistive device is surely a strength related metric as well. When comparing the average force production, non-assistive device (NAD) users generated force at rates of 13% greater than those that use an assistive device (AD). The standard deviation of both provides a potential threshold in which those who refuse an assistive device may very well benefit from one after testing for force production. Utilizing standard deviation places the lower threshold of non-assistive device users at 633 N, therefore this may illustrate an accurate measurement that motivates one to utilize such device.

4a.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average Force  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| AD | **734.55 N** | 37 | 57%  |
| Non AD Use | **842.83 N** | 23 | 47% |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Median Force  | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| AD  | **790.5 N**  | 32 | 49% |
| NAD | **794** | 24 | 49% |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| AD | 446.8 | 614.6 | 663.8 | 721.4 | 790.5 | 819.8 | 876 | 945.2 | 1047.5 | 1196.76 |
| NAD | 593.4 | 683.4 | 721.8 | 757.6 | 785 | 840 | 929.8 | 1012.2 | 1099.6 | 1427.32 |

Similar to force production, power output appears to represent an accurate strength measure as it relates to assistive device usage. When calculating statistical significance of both AD users (p value .011) and NAD users (p value .03), it can be stated the data accurately depicts a measurement of entire populations. Therefore, we can again compare the average and median among users and non-users, as well as the standard deviation that occurs between them. When comparing the norms among each, NAD users generate power at 34% greater rates than those who use an AD. The threshold for power output illustrates that those among the NAD users is equal to 175W, whereas AD users equals 80W, which represents over two fold difference.

4b.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average Power  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| AD | **215.28 W** | 28 | 43% |
| NAD | **330. 39W** | 18 | 37% |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Median Power | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| AD | **197.5 W**  | 32 | 49% |
| NAD | **294 W** | 24 | 49% |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| AD | 106.2 | 129.6 | 144.1 | 162.2 | 197.5 | 227.8 | 260.9 | 297.6 | 352.7 | 678.08  |
| NAD | 181.6 | 212.6 | 243 | 269.2 | 294 | 319.8 | 362.2 | 451 | 496 | 871.96 |

One might expect NAD users to outperform AD users when it comes to balance as an AD is often seen as a device used for a balance deficiency. While the data in figure 4c. does indicate that this is true, it would be unfair to say this is absolute truth as the data did not represent a statically significant outcome, AD user (p value = .77), NAD users (p value = .19). The results point toward AD use as a deficiency related to strength more so than static balance.

4c .

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average Area of Ellipse  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| AD | **464.48 mm Sq**  | 54 | 83% |
| NAD | **98.51 mm Sq** | 35 | 71% |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Median Area of Ellipse  | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| AD | **117 mm Sq**  | 15 | 23% |
| NAD | **76 mm Sq** | 24 | 49% |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| AD | 468 | 243 | 197 | 163 | 117 | 88 | 67 | 45 | 34 | 16.4 |
| NAD | 194.6 | 152.8 | 96.8 | 89.2 | 76 | 61 | 50.4 | 46 | 34.8 | 14.28 |

Stair climbing seems to be one of the many concerns of families as their loved ones continue through the aging process. Again, stair climbing appears to be a metric utilized and often compared with balance. Many might say as one ages, their balance declines, and thus their ability to climb stairs also dwindles. However, the data shown in the figures below will illustrate a much different story.

Stair climbers (SC) generated greater force, 21% (average) and 11% (median) compared to their non-stair climbing (NSC) counterparts. After calculating for statical significance it was determined the stair climbers (p value = .0002) and non-stair climbers (p value = .03) represented an accurate measurement of an entire population. With that said, we can note the difference in both average and median force output among both groups. Utilizing the standard deviation of stair climbers (225 N), can generate a lower threshold (606 N), in which those who may be unaware of their ability may indeed be able to climb the stairs.

5a.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average Force  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| Stair Climbers  | **831.68 N** | 36 | 46% |
| Non Stair Climbers | **664.71**  | 21 | 60% |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Median Force  | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| Stair Climbers  | **812 N**  | 39 | 49% |
| Non Stair Climbers | **727 N** | 17 | 49% |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| SC | 592.6 | 672.6 | 721.2 | 765.8 | 812 | 840.4 | 921.6 | 1025.8 | 1108.6 | 1373.03 |
| NSC | 184.38 | 580.2 | 632.4 | 664.6 | 727 | 790 | 819.8 | 886.6 | 945 | 1085.12 |

Power output among stair climbers and non-stair climbers varied similarly to force production (31%). However, when determining statistical significance, it was found that those who can climb the stairs represented an accurate illustration of the population (p value = 0.05), but those that do not climb the stairs did not (p value = .17). The insignificance created may be due to the methods in which data was collected (self-guided questionnaire). Those who said they cannot climb the stairs may have said so due to the simple fact of not having to climb stairs for an extended period. Statistical significance among stair climbers allows us to utilize the standard deviation (153 W) to estimate a threshold (138 W) in which those may be able to climb the stairs based on power output measurements.

5b.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average Power  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| Stair Climbers  | **291.46 W** | 30 | 38% |
| Non Stair Climbers | **212.49** | 14 | 40% |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Median Power  | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| Stair Climbers  | **269 W**  | 37 | 47% |
| Non Stair Climbers  | **176 W**  | 17 | 49% |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| SC | 155 | 184.8 | 211.1 | 229.6 | 269 | 286.6 | 312.3 | 362.2 | 473.2 | 756.54 |
| NSC | 45.78 | 121.6 | 131.8 | 149.8 | 176 | 208.4 | 265 | 339.2 | 398 | 640.9  |

When calculating for statical significance as it relates to stair climbers (p value = .81) and non-stair climbers (p value = .48), it can be stated that these data points do not accurately depict entire populations. Although variance is shown between the two groups, we cannot accept this as statically significance due to the wide range of data provided on both sides of the equation.

5c.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Average Area of Ellipse  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| Stair Climbers  | **341.69 mm Sq**  | 71 | 90% |
| Non Stair Climbers | **200 mm Sq**  | 24 | 69% |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Median Area of Ellipse  | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| Stair Climbers  | **86 mm Sq**  | 38 | 48% |
| Non Stair Climbers | **127 mm SQ**  | 16 | 46% |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| SC | 268.4 | 174.6 | 128 | 94.6 | 86 | 73.4 | 55.8 | 45.2 | 34 | 12.8 |
| NSC | 299.4 | 231.6 | 186.2 | 168 | 127 | 68.6 | 54.6 | 48.8 | 41.6 | 19.28 |

Much of what we believe to occur in the aging process appears to happen as the aging process continues and on. With that said, one might expect those who are younger to perform greater on the battery of tests we put together. While that may be true in some cases, it is not always true. After calculating for statistical significance regarding force output we noted that each sub group, 70-79 (p value= .0006), 80-89 (p value = .003), and 90-99 (p value = .0049) accurately represent populations within their own cohort. This is of grave importance because in the data below (figure 6a) there is a considerable difference, 19% (average) and 10% (median) when comparing those in their 7th generation between those in their 8th. As an individual continues to their 9th generation there appears to be little variance between force production when comparing 8th and 9th generation individuals. This is of particular interest because it may indicate there is a common downfall when an individual is 80 years old, thus indicating the importance of building a base prior to the new decade.

6a.

|  |  |  |  |
| --- | --- | --- | --- |
| Age  | Average Force  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| 70-79 | **918.69** | 7 | 44% |
| 80-89  | **748.16** | 34 | 58% |
| 90-99 | **755.71** | 19 | 56% |

|  |  |  |  |
| --- | --- | --- | --- |
| Age | Median Force (SC)  | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| 70-79 | **873.5** | 8 | 50% |
| 80-89 | **788** | 27 | 46% |
| 90-99 | **780** | 17 | 50% |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| 70-79 | 637 | 702 | 748.5 | 834 | 873.5 | 986 | 1037 | 1064 | 1137.5 | 1574.35 |
| 80-89 | 537.4 | 632.4 | 667.4 | 748 | 788 | 820.6 | 864.8 | 935.8 | 1015.8 | 1128 |
| 90-99 | 480 | 629.4 | 684.6 | 730.2 | 780 | 804.8 | 885.8 | 939.2 | 1070.8 | 1230.6  |

A similar decline is apparent when comparing power output to those in their 7th decade versus the 8th decade and beyond. In the data below (figure 6b) the average power output varies by 28% while the median power output varies by 14% (70-79 vs. 80-89). Again, the decline is minimal when comparing those in their 8th decade versus the 9th. However, the data collection did not provide an accurate representation of population for any of the cohorts below as 70-79 (p value = .14), 80-89 (p value = .07), 90-99 (p value = .07). Although there certainly appears to be a relationship between the two, the data did not produce results within the statical significance parameters to be at a level of 95% confidence.

6b.

|  |  |  |  |
| --- | --- | --- | --- |
| Age  | Average Power | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| 70-79 | **347.63 W**  | 4 | 25%  |
| 80-89  | **253.65** | 28 | 47% |
| 90-99 | **238.38** | 15 | 44% |

|  |  |  |  |
| --- | --- | --- | --- |
| Age | Median Power  | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| 70-79 | **288** | 8 | 50% |
| 80-89 | **249** | 28 | 47% |
| 90-99 | **208.5** | 17 | 50% |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| 70-79 | 183 | 211 | 215.5 | 222 | 288 | 293 | 338.5 | 356 | 604.5 | 1003.3 |
| 80-89 | 120.6 | 138.6 | 187.2 | 213.2 | 249 | 269 | 303.2 | 342.8 | 451 | 606.12 |
| 90-99 | 123.7 | 139.4 | 159.6 | 184.2 | 208.5 | 241.4 | 305.1 | 330 | 369.2 | 589.25 |

Beyond the age of 65, we cannot discuss balance in relation to their age simply because there are many different factors that play a role in balance. The data below shows a great deal of variance without an accurate representation of populations due to the elevated p values, (70-79; p value = .53), (80-89; p value = .82), and (90-99; p value = .75).

6c.

|  |  |  |  |
| --- | --- | --- | --- |
| Age  | Average Area of Ellipse  | Number of Participants Who Outperform the Average  | Percentage of Participants Who Outperform the Average |
| 70-79 | **182.06**  | 13 | 81% |
| 80-89  | **347.87** | 51 | 86% |
| 90-99 | **316.33** | 30 | 88% |

|  |  |  |  |
| --- | --- | --- | --- |
| Age | Median Area of Ellipse  | Number of Participants Who Outperform the Median | Percentage of Participants Who Outperform the Median |
| 70-79 | **82.5** | 8 | 50% |
| 80-89 | **83** | 27 | 46% |
| 90-99 | **128** | 16 | 47% |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 10th | 20th | 30th  | 40th  | 50th  | 60th | 70th  | 80th  | 90th  | 99th  |
| 70-79 | 447.5 | 128 | 106.5 | 86 | 82.5 | 76 | 69.5 | 46 | 38 | 17.15 |
| 80-89 | 258.6 | 194.6 | 136 | 96.2 | 83 | 55.6 | 48.2 | 44.2 | 34.4 | 24.16 |
| 90-99 | 281 | 250.2 | 173.8 | 164.6 | 128 | 106.8 | 67.4 | 57.6 | 45.4 | 20.96 |

**Discussion**

When comparing male and female cohorts among aging populations, there often exists an observable difference. Surely, there will be instances in which a male is far frailer than their female counterpart, but when viewing the entire cohort, we observed differences in all metrics (force, power and balance). Although force was the only metric that provided a statistically significant representation of both populations, we can see the observed relationship between force and power, as well as force and balance. Those who generated greater force production often generated greater power output, as well as increased balance metrics (a smaller area of ellipse). The data confirms it would be inaccurate for our team to compare the entire population. Males and females must be separated when determining needs and program strategy to improve health and well-being.

We expected a much larger variance between IL and AL residents as it relates to the force production. The variance of 5% between the two cohorts does not come as eye opening data. However, when utilizing the standard deviation to understand the lower range in which these individuals score, we may be able to understand what an accurate cutoff may be for those who are residing with IL but should really be in AL. It was found, the lower range for those within IL would generate force (583 N) or 27% less than the average IL resident. This correlates with the percentile ranks in which a score of 583 N would place an individual just beyond the 10th percentile of all IL residents, potentially signifying this individual may benefit from AL placement based on their strength parameters.

Power output was found to be accurately represented among IL residents, which would allow us to create the same recommendations for those who do not generate power output at numbers related to their peers. Recall, power output is an important metric when determining physical functioning in later life. Again, utilizing the standard deviation to understand the lower range for power output among IL residents places the power output at 156 W or within the 15th percentile (figure 3b). Based on the finding from both force production and power output, we may be able to begin making inferences about one’s need for a greater level of care based strength parameters (physical functioning).

Functional tests such as use of AD and stair climb produced promising results as we were able to note a statistically significant difference between the two, with SC and NAD users outperforming the NSC and AD users in both force production and power output. Similar to generating recommendations for greater levels of care, we can make inferences about those who may consider use of a walker or cane. When taking standard deviation into consideration, the lower range for force production of non-AD users equals 633 N or 25% less than the average NAD user, therefore those who produce force at rates less than 633 N may very well benefit from a walker, cane or exercise to improve their strength. We can make the same inferences with regard to power output. The lower range for NAD users equals 175 W, a score less than that of the 10th percentile (figure 4b), therefore those with power and force scores lower than the thresholds mentioned (633 N & 175 W) would likely benefit from use of an assistive device. Those who wish to step away from an AD must generate scores greater than the threshold. If there *still* exists a need for an AD then we must evaluate other variables that may be playing a role in AD usage.

The stairs often represent an area of concern for many families due to the balance deficiencies that may present themselves in later years. However, we found zero correlation with our quiet stand balance test with ability to climb stairs. A potential flaw may be the use of a self-guided questionnaire to collect data and the nature of the balance test (static) compared with stairs (dynamic). With that said, it is important to understand how force and power play a role in stair climbing as well. Many may choose to avoid the stairs because they do not believe they are possible. However, when calculating the ability of stair climbers, we come away with averages as well as lower ranges in which an individual must score in order to align with their stair climbing peers. Similar things can be said about those who have not climbed stairs in some time, those producing force and power above the lower thresholds for both may very well be able to do so. Force production of 606 N and power output of 138 W is the threshold in which individuals may be able to climb stairs provided there are no other variables that may prevent on from doing so such as immobility, cardiovascular endurance, etc.

Age is often a deterrent for many to begin exercise or to take the necessary steps to improve their health. Retirement, and even periods prior to, are often the stage in which individuals choose to ‘turn off’ their health and focus on the joy that is ahead, freedom. However, this often creates an open-door policy for muscle atrophy, chronic conditions, and poor health to begin its effect now and many years to come. When viewing the aging population, we did not expect our results to be affected by age in a statically significant manner due to the variance that can occur for individuals within the same cohort. Everyone in the senior care or healthcare industry knows there can be a 90-year-old who ‘runs circles’ around many of the 70-year-old individuals they encounter. With that said, our data revealed an interesting trend. Those in their 70s and 80s differ significantly in force and power production. However, when comparing those in their 80s with individuals in their 90s, the variance was relatively minute. This reveals the importance of those as they approach 80 years old, the decline may be very drastic unless measures are taken to prevent said decline. Considering the advances in healthcare, this potentially means an individual may live upwards of 20+ years in a state far different than how they felt, performed, and lived while they were in their 70s. This is a growing trend that we continue to see, lifespan continues to increase while healthspan remains stagnant. We must take the necessary steps to allow individuals to increase their healthspan in a linear fashion with their lifespan.

**Conclusion**

Force production and power output should be considered among the measurable factors when assessing older adults. The VALD Health ForcePlates allow for practioners to use such technology within a clinic or on the go. The study demonstrates uses of both force and power measurements relating to older population regarding their level of care needs, as well as assistive device usage. Further testing is needed to understand how static balance plays a role in the physical functioning of older adults. We believe this to be an important step in the right direction as it relates to strength testing among older adults.