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Differences in Walking Mechanics between a Traditional Walker and the KB Balance Trainer

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DIFFERENCES IN WALKING MECHANICS BETWEEN A TRADITIONAL WALKER AND THE KB BALANCE TRAINER

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the Master of Science in Nutrition and Exercise Science degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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ABBREVIATIONS

2WW	2 Wheels Walker
3WW	3 Wheels Walker
4LW	4 Legs Walker
4WW	4 Wheels Walker
ADL	Activities of Daily Living
BOS	Base of Support
C	Cane
COM	Center of Mass
CSA	Cross Sectional Analysis
FTSST	Five Times Sit to Stand Test
KB	KB Balance Trainer
PIADS	Psychosocial Impact of Assistive Devices Scale
POMA-B	Performance Oriented Mobility Assessment.
QUEST	Quebec User
ROM	Range of Motion
TUG	Time Up and Go
TW	Traditional Walker
UW	Unassisted Walking
WW	Wheeled Walker

ABSTRACT

DIFFERENCES IN WALKING MECHANICS BETWEEN A TRADITIONAL WALKER AND THE KB BALANCE TRAINER

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INTRODUCTION: Millions of individuals with ambulatory difficulties rely on walking aids to maintain independence and mobility. However, users of traditional walkers typically exhibit increased forward lean of their trunk while using the assistive device. The KB Balance Trainer is a new posterior walker designed to facilitate a more erect position during gait. PURPOSE: To compare gait mechanics across three walking conditions: unassisted, using a traditional walker, and using the KB Balance Trainer. METHODS: Seven adults with experience using walkers due to ambulatory difficulties participated in the study. The study consisted of one training session and one gait analysis session. The training session was 30 minutes of instruction and practice on how to properly use each assistive device. During the data collection, participants walked on flat ground in three walking conditions at a self-selected speed: walking with the traditional walker (TW), the KB Balance Trainer (KB), or unassisted (UW). RESULTS, DISCUSSION, CONCLUSION: Gait speed increased similarly while using both assisted devices compared to unassisted walking, showing that the KB was as effective as the TW to aid in mobility. The KB showed slightly less mean trunk flexion than the TW. However, mean trunk flexion was greater while using either device compared to unassisted walking. Therefore, neither device was able to promote erect posture. In addition, hand to hip distance showed that participants incorrectly used the KB Balance

Trainer. It is possible that the KB Balance Trainer can facilitate a more erect posture than a traditional walker if sufficient training is provided and if it is used correctly.

1. Introduction

In 2016 more than 10 million individuals age 65 and older had ambulatory difficulties in the U.S. alone [1]. To offset these difficulties, assistive walking aids, such as a cane or a walker, are often adopted [2]. Walking aids have physical and psychological benefits which can help the users to regain mobility and independence [3]. Users are then able to maintain a certain level of physical activity which is fundamental for overall health [4].

Despite the many advantages, if used incorrectly, assistive device can increase the risk of falling or abandoning the device [3, 5, 6]. Walking aids are often used incorrectly and forward leaning of the trunk is one of the most common and concerning trends [7, 8]. This increased forward leaning posture may arise from the users translating their center of mass (COM) forward in the attempt to adjust to the larger base of support (BOS) created by the walker [9, 10]. Furthermore, the lean could be the result of choosing an inadequate aid or an incorrect height setting [7].

The forward lean of the trunk may increase the risk for falling. Falls are one of the leading causes of death from injuries in elderly and can also result in long-lasting debilitating conditions which can reduce the users' quality of life [11]. Furthermore, fear of falling is common among older adults and it may influence users to limit their daily activities and become less independent [12, 13]. In addition to falling, leaning forward while walking results in unnatural gait mechanics [7, 14]. The continuous use of the device under these conditions may then result in the user adapting to and relying on the additional somatosensory input from the walker. This adaptation can eventually lead to long-term dependency on the walker [8, 14, 15].

Consequently, the traditional structure of current aids and using them incorrectly may not maximize safety nor facilitate correct body alignment. In the attempt to reduce the forward leaning often observed in persons using a traditional walker and to help reduce the dependency on the walker as an assistive device, the KB Balance Trainer was created. The KB Balance Trainer is a new posterior walker that is designed to facilitate a more erect posture during gait. The KB Balance Trainer is designed to wrap behind the user while providing an opening in front to simulate unassisted walking. The handles are designed to encourage the users to push their arms and shoulders downward close to their hips and the chest upward to create a more erect posture. The handles by the hips is intended to discourage the users from leaning their weight forward. Finally, the center wheels are also positioned in line with the users' hip. These wheels are designed to act as a rocker, allowing the hip to rock forward and freely swing during gait. Despite the anecdotal evidence from patients, claiming that the KB Balance Trainer enable them to maintain a good posture, there is the need to validate this tool and its effectiveness.

Therefore, the primary purpose of the study is to compare the gait mechanics between a traditional walker, the KB Balance Trainer, and unassisted walking. The secondary purpose is to assess the users' satisfaction with their current device, the traditional walker, and the KB Balance Trainer. We hypothesize that the KB Balance Trainer will provide a more erect posture compared to the traditional walker. The posterior frame of the walker will prevent the anterior lean of the trunk and it will keep the users' COM between their feet. We also hypothesize that the KB Balance Trainer will show spatio-temporal variables similar to the traditional walker in order to assist the user in walking. Finally, we also hypothesize that the users' overall satisfaction of their current devices will be similar to those found in previous studies [16, 17].

The findings of this study will help determine the effectiveness of the KB Balance Trainer in achieving its' designed purpose, a more natural upright gait pattern. If this new device will be able to show gait mechanics similar to regular walking, it could open up new possibilities for users to regaining postural control, walking unaided, and likely reducing their risk for falling. This device has the potential to aid users to continue an independent life, and to improve mobility, which is fundamental for overall health and longevity.

2. Methods

2.1 Participants

Seven adults (5 women, 2 men, age: 69.4 ± 16 (48 to 89) yrs.; height: 1.67 ± 0.1 m; mass: 101 ± 19 kg) with self-reported difficulty walking and currently using a walker participated in the study. Participants were recruited from the community of Brookings, SD and surrounding areas. Adults of any age currently using an assistive device were included in the study. Individuals with a current injury or those who recently had major orthopedic surgery in the past three months were excluded from the study to avoid finding significant gait differences as result of the injuries or surgery. All participants provided informed consent and the study was approved by the South Dakota State University Institutional Review Board.

2.2 Procedure

The study consisted of two consecutive visits: a training session and a gait analysis session. The gait analysis, performed within 24 to 48 hours following the training session, compared three walking conditions: walking with a traditional walker, walking with the KB Balance Trainer, and walking unassisted.

2.2.1 The walkers

The KB Balance Trainer (Figure 1) is a posterior walker with a reverse brake system. The posterior frame surrounds users around their side and back while providing an opening in front to simulate unassisted walking. The Palm Pads are used as handles and brakes. The walker is in the locked position at all times when the Palm Pads are up (Figure 2a). The brakes are released only when the users push down on the Palm Pads (Figure 2b). Users are trained to press down on the Palm Pad with their palm while placing their torso in an upright position in line with the hips. Finally, the center wheels are also positioned in line with the users' hip. These wheels are designed to act as a rocker, allowing the hip to rock forward and freely swing during gait.

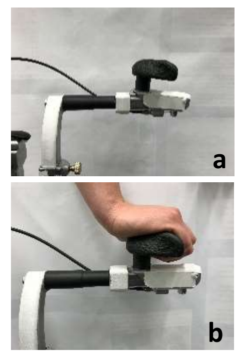

Figure 2. Palm Pads.
a) locked position.
b) unlocked position.

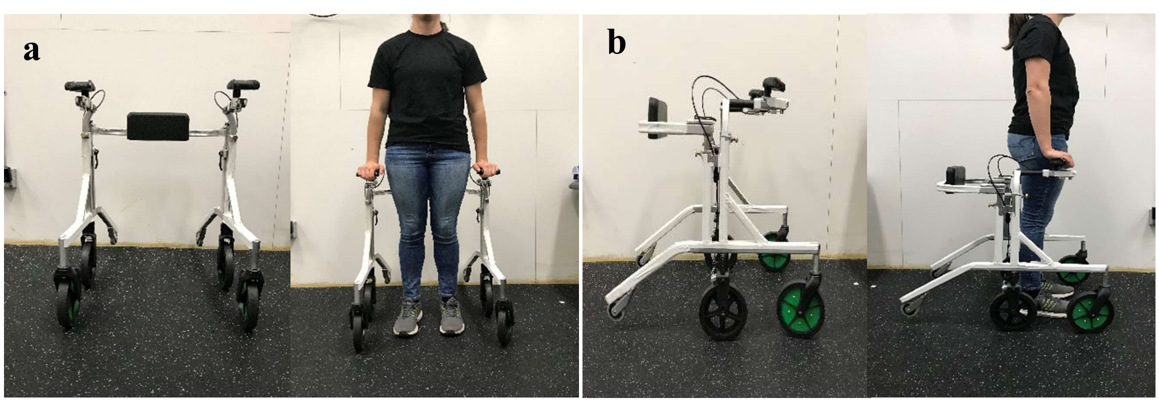

Figure 1: KB Balance Trainer. a) frontal view. b) sagittal view.

The traditional walker (Figure 3) was a Drive Clever-Lite Walker, Adult with 5” wheels. It was chosen because its four wheels and rectangular frame most closely compares to the KB Balance Trainer. It is also a commonly prescribed walker by Physical Therapist and other health care providers and is usually covered by insurance. It has an anterior frame and a standard brake system below the traditional tubular handles (Figure 4).

Figure 4. Traditional brake system.

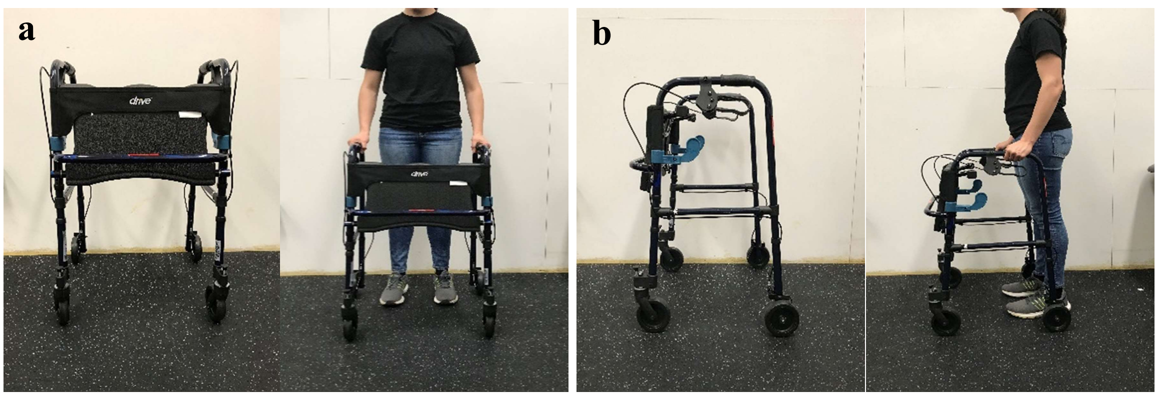

Figure 3. Traditional walker. a) frontal view. b) sagittal view.

2.2.2 Training session

During the first session, each participant completed a health-history questionnaire, PAR-Q, and satisfaction survey on the current walking aid used. The satisfaction survey of the users’ current walking device included the Device Section of the Quebec User Evaluation Satisfaction with assistive Technology (QUEST) which has been shown to be valid and reliable in assessing satisfaction outcomes in diverse population [18-20]. In the QUEST, the participants rated eight items (dimension, weight, adjustments, safety, durability, ease to use, comfort, and effectiveness) on a scale from 1 to 5, from not satisfied at all to very satisfied. Following the completion of all forms, the researcher fitted each walker to the participants' individual characteristics. Based on previously established guidelines, the traditional walker's handles were adjusted to the user's wrist crease, which allowed for a 30-degree angle at the elbow [21]. The KB Balance Trainer's Palm Pads were adjusted based on the manufacture recommendations. Participants were asked to stand inside the assistive device with arms relaxed to the side and wrists extended with palms parallel to the floor. The Palm Pads were then adjusted to the height of the palms. Participants were first trained on how to properly use each assistive device. Participants were then given 30 minutes to familiarize themselves with each walking aid while researchers provided cuing on proper use of the device. At the beginning and end of the training session, participants were asked to rate their confidence and safety perception on using each of the walkers. This survey was used to assess training effectiveness and to rate users' confidence before data collection.

2.2.3 Experimental Set-up

During the second visit, the participants completed the gait analysis. Researchers provided standardized footwear (Nike Pegasus) and running shorts before applying retroreflective markers on the torso, feet, and dominant leg of the participants using a modified Helen Hayes market set. The markers were applied to the following landmarks: seventh cervical vertebra, sternoclavicular notch, acromion processed, right scapular inferior angle, tenth thoracic vertebra, greater trochanters of the femur, medial and lateral epicondyles of the femur, medial and lateral malleoli, proximal heel, distal heel, lateral heel, distal end of the first, second, and fifth metatarsal, and distal end of the feet. In addition to individual markers, three marker clusters were applied on the thigh and shank of the dominant leg and on the sacrum. Finally, the anterior superior iliac spines (ASIS) and the iliac crests (IC) landmarks were identified using a spring-loaded digitizing pointer (C-Motion, Germantown, MD) (figure 5) to account for excess adiposity in the hip area. The digitizing pointer and this specific marker set were shown to increase accuracy in overweight and obese individuals compared to applying markers on the skin [22]. Virtual markers for the ASIS and IC landmarks were then digitally created in Visual 3-D during data processing. An eight camera Qualisys motion capture system was used to collect kinematics data at 200Hz.

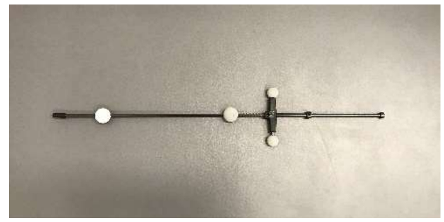

Figure 5. Spring digitating pointer.

2.2.4 Experimental Procedures

Following a static calibration, anatomical markers were removed and participants randomly completed a series of five walking trials for six different conditions. The randomized conditions included walking unassisted, using the traditional walker, and using the KB Balance Trainer, each at two speeds (self-selected and as fast as safely possible). The self-selected trials were performed to collect data on the most natural gait movement. The fast trials were performed to observe which device would allow the users to reach the fastest velocity, and to assess users' confidence while using each assisted device. The order of the walking trial conditions was randomized for each participant and at least three trials per set were performed with a minimum of one to three minutes of rest between trials and sets. If the participant was unable to walk unassisted, the two sets of unassisted walking were not performed. All participants completed the unassisted walking at self-selected speed, while one participant did not perform the fast, unassisted trials. At the end of the session, participants completed a satisfaction survey about each assistive device: the KB Balance Trainer and the traditional walker.

2.3 Data analysis

2.3.1 Data Reduction and Processing

For all walking trials, kinematics data and walking speeds were recorded. Kinematics data were analyzed for the entire gait cycle, defined as one stride starting from the dominant foot toe off and ending with the successive dominant foot toe off. Data was then exported and analyzed with Visual 3-D (C-Motion, Inc.; Germantown, MD). Kinematic data was filtered with a 6Hz Butterworth filter. The temporal variables of interest were gait speed, stance time, swing time, step time, and double support time. The spatial variables of interest were stride length, step length, and step width.

In addition, angular displacement of the hip, knee, and ankle joints of the dominant leg were measured. Joint angles were calculated in the sagittal plane using the *X, Y, Z* Euler angle rotation sequence in Visual 3-D. Angles were normalized to the standing calibration. Peak flexion and extension, as well as ROM were measured for each joint during stance, swing, and the entire gait cycle. Trunk segment angle was also calculated in the sagittal plane with respect to the vertical axis of the lab coordinate system. Mean trunk flexion and trunk ROM were calculated to assess the participants' posture. The height of the participants' COM as well as the distance from the hand's retroreflective marker and the hip joint in the sagittal plane were also used to assess trunk lean. Each kinematic variable was averaged across three successful walking trials and compared across the three walking conditions.

2.3.2 Statistical Analysis

Mean and standard deviation were calculated for all variables. Median and range were used to compare subjective survey data between the two assistive devices. Median and range were chosen in this context because they may provide greater insight on the participants' responses when rating satisfaction on a subjective scale. Percent difference was used to compare all other variables between the three conditions. Statistical significance was not displayed because the data was underpowered. Percent difference between two conditions was determined by calculating the mean of the differences between conditions for each participant, and divided it by the mean of the reference condition. UW was the reference condition when comparing KB to UW and TW to UW. TW was the reference condition when comparing the two assistive devices. Percent differences above 10% are highlighted in this paper to show a possible clinically meaningful difference between conditions.

3. Results

3.1 Demographics

Seven adults (five females and two males) with difficulty walking participated in the study. All participants (age: 69.4 ± 16 (48 to 89) yrs; height: 1.67 ± 0.1 m; mass: 101 ± 19 kg) were currently using an assistive device. They had experience using their current device for more than a year and were using it most of the time during the day for mobility related activities. Additional participants' characteristics are shown in Table 1.

Table 1. Additional participants' demographics.

Current assistive device:	n
4WW	3
2WW	2
Cane	2
How it was acquired:	
Self	3
Medical professional	4
Trained to use device:	3
Current Diagnosis:	
Diabetes	2
Multiple Sclerosis	1
Parkinson	1
Past orthopedics surgeries:	
Knee Replacement	2
Hip Replacement	2
Leg or foot fractures	4

WW: Wheels Walker

3.2 Spatial and temporal variables

Self-selected gait speed among the KB and TW conditions was similar (Table 2). Gait speed for the KB and TW conditions were faster than the UW condition by 12.4% and 12.2%, respectively. Step and stride length were also larger while using an assistive device compared to UW. Step width was larger during the UW condition compared to both the KB (29.2% difference) and TW (23.2% difference). No other meaningful percent difference was found between the three conditions.

Table 2: Gait spatial and temporal variables among the three conditions.

	Mean ± SD		Percent Difference
Gait speed (m/s)	KB	0.73 ± 0.2	KB > TW 0.26%
	TW	0.73 ± 0.1	**TW > UW 12.2%**
	UW	0.65 ± 0.2	**KB > UW 12.4%**
Stride length (m)	KB	0.87 ± 0.2	TW > KB 3.72%
	TW	0.90 ± 0.1	**TW > UW 17.6%**
	UW	0.77 ± 0.2	**KB > UW 13.2%**
Step length (m)	KB	0.43 ± 0.1	TW > KB 3.88%
	TW	0.45 ± 0.1	**TW > UW 17.6%**
	UW	0.38 ± 0.1	**KB > UW 13.1%**
Step width (m)	KB	0.11 ± 0.03	TW > KB 7.79%
	TW	0.12 ± 0.04	**UW > TW 23.2%**
	UW	0.16 ± 0.04	**UW > KB 29.2%**
Stance time (s)	KB	0.81 ± 0.1	KB > TW 3.07%
	TW	0.78 ± 0.1	TW > UW 3.58%
	UW	0.78 ± 0.2	KB > UW 0.50%
Swing time (s)	KB	0.41 ± 0.1	TW > KB 1.64%
	TW	0.42 ± 0.04	TW > UW 0.26%
	UW	0.41 ± 0.1	UW > KB 1.38%
Step time (s)	KB	0.61 ± 0.1	TW > KB 2.85%
	TW	0.63 ± 0.1	UW > TW 1.46%
	UW	0.64 ± 0.1	UW > KB 4.28%
Double support time (s)	KB	0.40 ± 0.1	KB > TW 0.36%
	TW	0.40 ± 0.1	UW > TW 7.39%
	UW	0.43 ± 0.1	UW > KB 7.06%

m: meters; s: seconds; KB: KB Balance Trainer, TW: Traditional Walker; UW: Unassisted Walking.

While walking as fast as safely possible, gait speed was found to be 0.99 ± 0.2 m/s in the KB, and 1.03 ± 0.2 m/s in the TW. During these fast trials, participants walked 4.18% faster with the TW versus the KB. Compared to self-selected gait speed, the KB speed increased by 36.0%, while the TW speed increased by 42.3%.

3.2 Angular Kinematics

Ankle, knee, and hip mean angles curves were plotted in the sagittal plane and are displayed in Figure 6-8. Each angle was normalized to 100% of one gait cycle, from the dominant foot toe off to the successive dominant foot toe off. Important events in the gait cycle such as the dominant foot heel strike (DF-HS), non-dominant foot heel strike (ND-HS) and toe off (ND-TO) are displayed on the graphs as well.

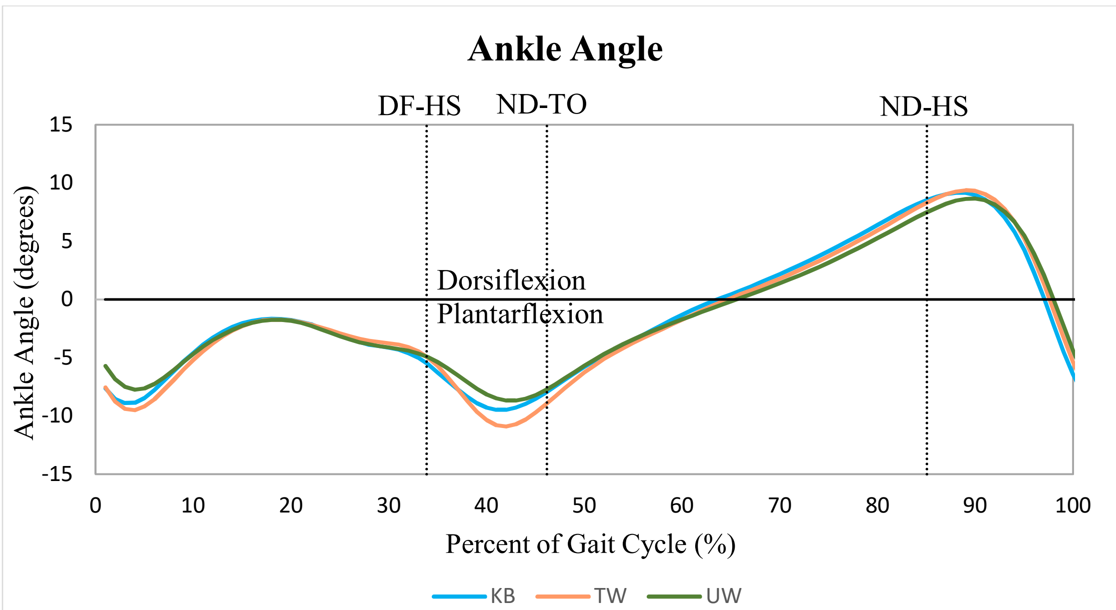

Figure 6. Ankle angle in the sagittal plane. Mean value of all participants for all 3 conditions. Scaled to 100% of one gait cycle, from the dominant foot toe off to the successive dominant foot toe off. KB: KB Balance Trainer. TW: Traditional walker. UW: Unassisted walking. DF-HS: dominant foot heel strike. ND-HS: non-dominant foot heel strike. ND-TO: non-dominant foot toe off.

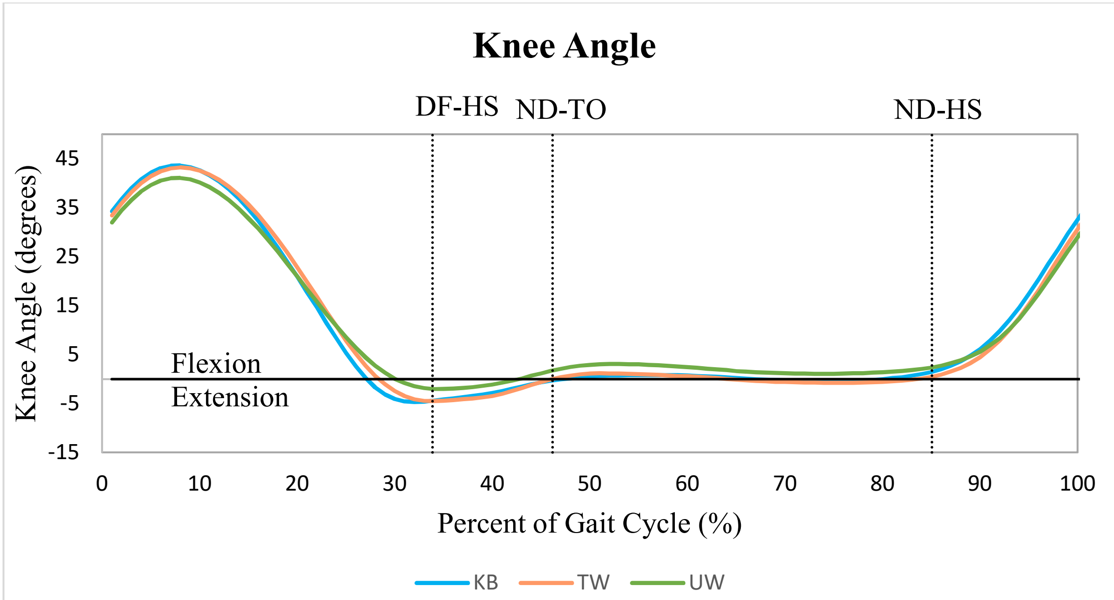

Figure 7. Knee angle in the sagittal plane for the three conditions. Values are averages of all seven participants. Scaled to 100% of one gait cycle, from the dominant foot toe off to the successive dominant foot toe off. KB: KB Balance Trainer. TW: Traditional walker. UW: Unassisted walking. DF-HS: dominant foot heel strike. ND-HS: non-dominant foot heel strike. ND-TO: non-dominant foot toe off.

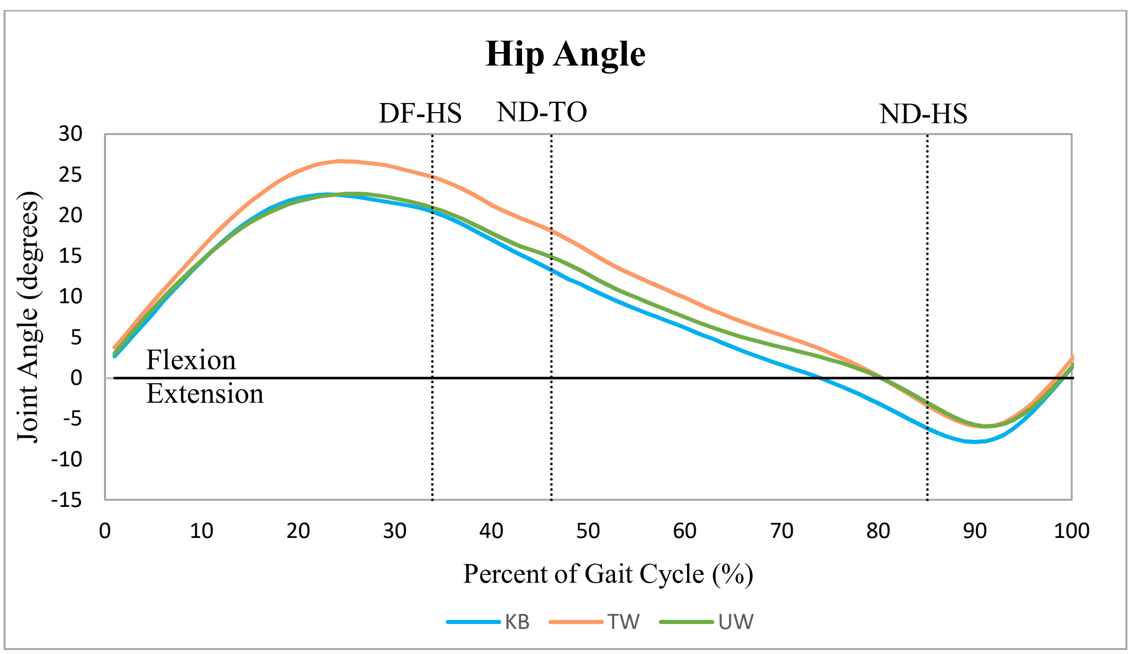

Figure 8. Hip angle in the sagittal plane for the three conditions. Values are averages of all seven participants. Scaled to 100% of one gait cycle, from the dominant foot toe off to the successive dominant foot toe off. KB: KB Balance Trainer. TW: Traditional walker. UW: Unassisted walking. DF-HS: dominant foot heel strike. ND-HS: non-dominant foot heel strike. ND-TO: non-dominant foot toe off.

Ankle angle ROM during the entire cycle was found to be 22.0 ± 5.1 degrees, 23.1 ± 5.0 degrees, and 22.8 ± 7.4 degrees in the KB, TW, and UW, respectively. Knee angle ROM during the entire cycle was found to be 51.4 ± 12 degrees, 50.0 ± 13 degrees, and 47.4 ± 13 degrees in the KB, TW, and UW, respectively. Hip angle ROM during the entire cycle was found to be 32.7 ± 9.0 degrees, 34.0 ± 7.3 degrees, and 31.0 ± 6.5 degrees, in the KB, TW, and UW, respectively. The percent differences between all conditions for all three joints were not found to be above 10%. No meaningful differences were also found when assessing ROM during the stance and swing phases separately. Peak flexion and extension were not reported because they did not display meaningful data due to the large variability between participants.

3.3 Trunk inclination assessment

The variables used to assess trunk inclination are shown in Table 2. Mean, max, and min hand distance between the hand and the hip was meaningfully larger during TW then KB. Mean trunk flexion in the TW was slightly greater than in the KB. In addition, mean trunk flexion were found to be larger in the TW and KB compared to UW.

Table 2. Summary of trunk inclination variables during entire gait cycle.

	Mean ± SD	Percent Difference
Mean trunk flexion (deg)	KB 4.98 ± 5.8 TW 5.94 ± 6.1 UW 2.38 ± 5.4	**TW > KB 16.2%** **TW > UW 109%** **KB > UW 150%**
Trunk ROM (deg)	KB 5.17 ± 2.0 TW 5.03 ± 1.8 UW 4.58 ± 1.8	KB > TW 2.74% TW > UW 9.73% KB > UW 12.7%

Min height of COM (m)	KB 0.96 ± 0.1 TW 0.95 ± 0.1 UW 0.96 ± 0.1	KB > TW 0.66% UW > TW 0.45% KB > UW 0.21%
Mean height of COM (m)	KB 0.97 ± 0.1 TW 0.97 ± 0.1 UW 0.97 ± 0.1	KB > TW 0.41% UW > TW 0.42% UW > KB 0.01%
Mean hand-hip distance (m)	KB 0.19 ± 0.1 TW 0.26 ± 0.1	**TW > KB 25.8%**
Max hand-hip distance (m)	KB 0.23 ± 0.1 TW 0.30 ± 0.1	**TW > KB 23.7%**
Min hand-hip distance (m)	KB 0.16 ± 0.1 TW 0.23 ± 0.1	**TW > KB 28.8%**

Deg: degrees; m: meters; ROM: range of motion; COM: center of mass; KB: KB Balance Trainer; TW: Traditional Walker; UW: Unassisted Walking.

Trunk angle curve in the sagittal plane is displayed in Figure 9. Hand distance in the sagittal plane from the hand marker to the hip is displayed in Figure 10. Both graphs are normalized to 100% gait cycle.

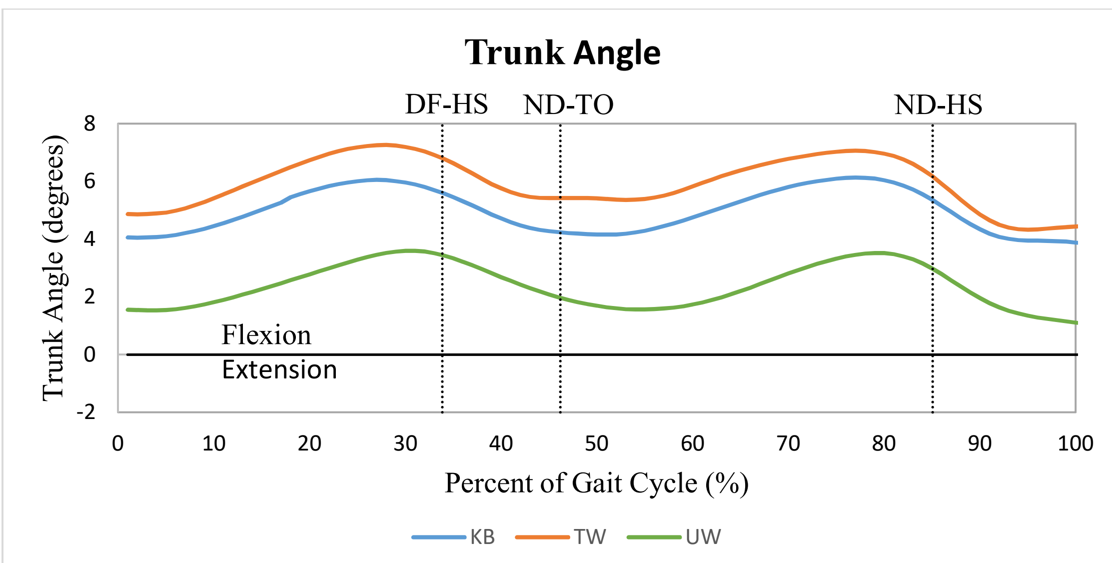

Figure 9. Trunk flexion and extension in relation to standing calibration in the sagittal plane for the three conditions. Values are averages of all seven participants. Scaled to 100% of one gait cycle, from the dominant foot toe off to the successive dominant foot toe off. KB: KB Balance Trainer. TW: Traditional walker. UW: Unassisted walking. DF-HS: dominant foot heel strike. ND-HS: non-dominant foot heel strike. ND-TO: non-dominant foot toe off.

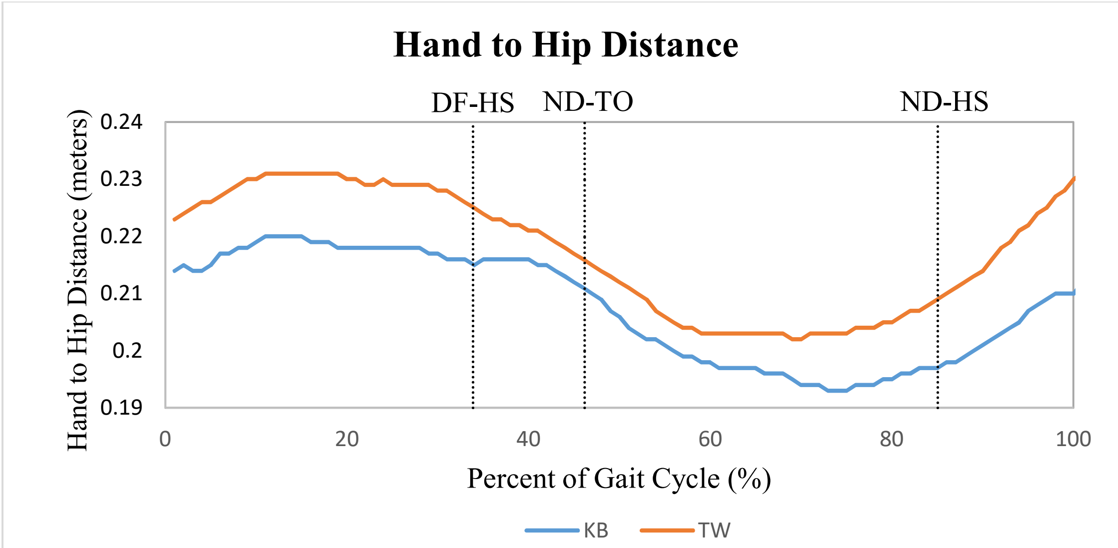

Figure 10. Hand to hip distance in the sagittal plane for the two assistive devices. Values are averages of all seven participants. Scaled to 100% of one gait cycle, from the dominant foot toe off to the successive dominant foot toe off. KB: KB Balance Trainer. TW: Traditional walker. DF-HS: dominant foot heel strike. ND-HS: non-dominant foot heel strike. ND-TO: non-dominant foot toe off.

3.3 Subjective data

Participants rated both the traditional walker and the KB Balance Trainer on several features on a scale from 1 to 10, 1 being poor and 10 being excellent (Table 3).

Table 3. Satisfaction scores for the KB Balance Trainer and the Traditional Walker

	Satisfaction	Fit	Confidence	Balance	Posture
KB	9 (6-9)	9 (5-10)	8 (6-10)	8 (7-10)	9 (7-10)
TW	8 (7-10)	8 (6-10)	9 (7-10)	9 (7-10)	7 (5-9)

Median (Range); KB: KB Balance Trainer; TW: Traditional Walker. Scores on a scale from 1 to 10, 1 being poor and 10 being excellent.

In addition, participants rated the difficulty in learning and using each device on a scale from 0 (no difficulty) to 10 (maximum difficulty). Median (range) difficulty in using the device was 3 (1-5) with the TW compared to 2 (1-3) with the KB. Median (range) difficulty in learning how to use the device was 1 (1-5) with the TW compared to 2 (1-4) with the KB.

3.4 Current aid satisfaction

Participants rated their currently assistive device using the Device portion of the QUEST 2.0. For all eight items, participants scored their current device above 4 out of 5, with a mean score of 4.25 out of 5. The highest rated item was comfort, and the lowest scoring item was durability.

4. Discussion

The primary purpose of the study was to compare the gait mechanics between a traditional walker, the KB Balance Trainer, and unassisted walking. We hypothesized that the KB Balance Trainer would provide a more erect posture compared to the traditional walker due to its innovative design. Based on previous literature, we also hypothesized that spatio-temporal variables during the KB condition would be similar to the TW condition in order to assist the user in walking. The most important findings of this study and their implications are discussed in the following sections.

4.1 Differences between the three conditions at self-selected speed

4.1.1 Spatial and temporal variables

Self-selected gait speed was higher during assisted walking (Table 2). This finding is consistent with the current body of literature that has shown increased mobility as one of the most common benefits of using an assistive device [3, 23, 24]. In addition to being a measure of health and survival in elderly, increased gait speed has been previously associated with higher quality of life in other populations such as patients suffering from stroke and multiple sclerosis (MS) [25, 26]. This finding also supports the second hypothesis of this study, showing that the KB allowed for a similar mobility benefits than the TW. Despite the increase in gait speed during KB and TW, in all three conditions in this study, participants still walked slower than 0.8 m/s, which has been used as a cutoff for frailty in elderly [27]. This is not surprising considering participants chosen in this study currently had difficulties walking.

Step and stride length were also greater in the KB and TW conditions compared to UW (Table 2). The longer steps in the KB and TW conditions may be responsible for the faster gait speed exhibited during the assisted conditions, since all other temporal variables showed no difference. Step width was wider during UW compared to walking with either of the assistive devices (Table 2). When walking unassisted, participants may have used wider steps to increase their base of support (BOS). A larger BOS can aid in stability and fall prevention [3]. When walking with a device, however, the BOS is already larger due to the frame of the walker. Furthermore, the assistive devices may limit the step width because the user is constrained by the frame of the device [3].

4.1.2 Angular kinematics

A unique aspect of this study was the investigation of joint kinematics with the use of a motion capture system. This is a novelty in this field as the majority of previous studies used instrumented walkways to assess spatial and temporal variables only. The addition of joint kinematics is important to assess the participants' total body movement and posture, that would be otherwise absent with the use of solely instrumented walkways.

Hip, knee, and ankle ROM were found to be similar between all three conditions. Joint angles curves are presented as a visual representation of the participants' movements and were used to compare between walking conditions. As seen in Figures 6-8, joint angle curves followed similar trajectories during all three conditions. The ankle and knee angles were similar between devices, while the hip angle appears to be different between TW and KB. During the swing phase, the TW displays greater hip flexion and during the stance phase the KB has more hip extension. Alkaer and colleagues [14] also found a difference in hip flexion during the stance phase when comparing walking with a 4WW and walking unassisted. The authors stated that the increased hip flexion was associated with an increased flexion of the trunk.

Although it appears that there is a difference in hip flexion in this study, these results should be interpreted with caution due to the high variability of the data. Future research using a single subject design or a larger sample size is needed to determine if hip flexion exhibited by users is in fact different between the two assistive devices.

4.1.2 Trunk lean assessment

Trunk segment angle curves, relative to a vertical reference line, show similar patterns for all walking conditions. However, the amount of trunk flexion appears to be least in the unassisted walking condition (Figure 9). Although it appears that the users displayed less trunk flexion while using the KB, results need to be interpreted with caution due to the high variability of the data. Figure 11 shows the amount of variability in trunk angle values. The figure shows the overlapping of trunk angle curves between both conditions (KB represented by solid lines, while TW represented by dotted lines). In addition, the figure displays individual differences between participants. Some participants appear to achieve a more upright posture with the KB, while others achieve it with the TW.

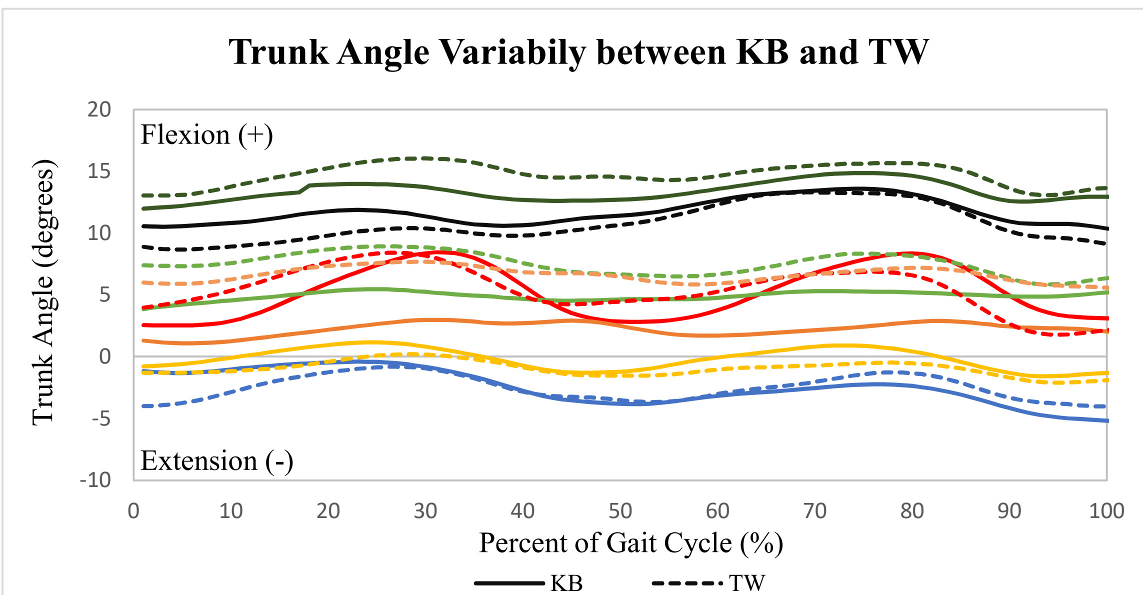

Figure 11. Trunk segment angle in relation to standing calibration in the sagittal plane for all participants. Each participant is a different color. Within each participant, solid line represents KB condition, while dotted line represents TW condition. Graph scaled to 100% of one gait cycle, from the dominant foot toe off to the successive dominant foot toe off. KB: KB Balance Trainer. TW: Traditional walker.

Both the KB and the TW exhibited greater inclination angles compared to UW, showing that neither device elicited an erect posture similar to UW. The larger inclination angle found when using a device compared to unassisted walking is consistent with previous studies [7, 12]. Although we are showing this trend, more participants are needed in order to accurately determine the impact of assistive devices on trunk inclination.

In addition to trunk inclination angle, hand to hip distance was used to assess users' posture. In this study the TW showed slightly larger hand to hip distance compared to the KB (Figure 10). In this context it is important to consider the difference in fitting recommendations between the two devices. While using the TW, the arms are supposed to be bent at 30 degrees, which positions the hands in front of the hips. In contrast, while using the KB, the arms are supposed to stay straight and in line with the body. Contrary to these recommendations, the hand position during the KB condition was found to be about 20 cm in front of the hips. Therefore, both the trunk inclination and hand positioning show signs of incorrect use of the KB Balance Trainer.

Devices may be used incorrectly because of fear of falling. However, confidence and feeling of safety while using the device was assessed at the end of the training session and all participants rated above 8 out of 10. In addition, to assess confidence in walking, participants were asked to walk as fast as safely possible. Fast gait speed was similar between both walkers, showing that participants were able to use the KB with the same confidence than the TW. Despite their confidence during the first session, the day of the data collection, some participants expressed their concern for the open-front style of the KB. The possible fear of falling forward may have influenced the users to move towards the back of the device. This strategy may have been a way to return to the position they were accustomed to with a traditional walker.

4.3 Current device satisfaction

Prior to participating in the study, participants were using canes, 2WW, and 4WW. Three out of seven participants bought the device themselves without medical supervision. Only three participants had any sort of training on how to property use it. This is concerning because lack of training is one of the possible factors leading to falls [7, 12]. Participants were asked to rate their current assistive device using the Device Portion of the QUEST Questionnaire. All participants rated their device above 4 (or "satisfied") in the Device portion of the QUEST. The mean final QUEST score was 4.25 out of 5. Satisfaction of assistive aids was previously assessed in other studies using the same questionnaire. Brandt et al. [16] found 92% satisfaction rate in first time walker users, while Samuelson et al. [28] found 90% satisfaction rate in daily walker users. The current study results best agree with Hill et al found a mean score of 4.5 in COPD patients [17].

Participants also rated the two assistive devices used in this study on several item on a scale from 1 to 10 (Table 3). Overall satisfaction, fit, confidence, balance, difficulty in learning and using the devices, had similar scores between the KB and TW. When participants were asked to rate their posture, the KB Balance Trainer scored higher median and range values compared to the traditional walker. Despite the incorrect use of the KB Balance Trainer, participants felt that they have made an improvement in posture with the KB Balance Trainer. This may be due to the novelty of its design.

4.4 Limitation and future direction:

Caution in interpreting the results of this study is recommended. The small sample size and high variability between participants precluded the use of traditional statistical assessment due to underpowered data. In addition, participants did not adopt correct technique when using the assistive devices. During the second session, users did not recall the training cues and employed the strategies they were already accustomed to. This is not surprising considering that they were long term users of traditional assistive devices. One training session was not enough to teach the skills needed to operate the KB Balance Trainer properly. It is possible that the KB Balance Trainer can facilitate a more erect posture during gait than a traditional walker if sufficient training is provided and the trainer is consistently used properly. More research is needed to determine if there are real differences in gait mechanics when the devices are used correctly. A longer training period and a larger sample size may be necessary to find data in support of the company's anecdotal evidence. Finally, since some participants appeared to have responded differently than others to the new device, a single subject design may be more appropriate in determining differences in those individuals.

5. Conclusion

The KB Balance Trainer was found to have similar benefits than a traditional walker in helping participants increase their gait speed. However, the KB Balance Trainer was not able to elicit erect posture and was found to have higher trunk flexion compared to unassisted walking. This results may be influenced by the incorrect use of the device, which may have decreased the effectiveness of its innovative design. If participants use the KB Balance Trainer correctly there is the potential to improve gait mechanics. Future research with a larger sample size and a longer training period is necessary to determine if there are differences between the KB Balance Trainer and traditional assistive devices.

Literature Review

The literature review consists of four sections: benefits of using a walking aid; demands, risk, and barriers of using a walking aid; satisfaction when using a walking aid; and mechanical difference when using a walking aid. The purpose of the first two tables is to highlight the positive and negative aspects of walking devices. Table 1, *Benefits of using a walking aid*, identifies the major reasons why these devices are popularly chosen or prescribed. Table 2, *Demands, risk, and barriers of using a walking aid*, provides reasons why these devices are sometimes abandoned. Table 3, *Satisfaction when using a walking aid*, focuses on users' satisfaction as a sum of the device benefits and demands. Table 4, *Mechanical difference when using a walking aid*, is a review of the previous studies that investigated gait mechanics of walking with several types of assistive aids.

Table 1 summarizes the benefits of using a walking aid. This table shows that assistive devices have both physical and psychological benefits. Physically, the walking aid provides additional stability and support, and increases mobility. Psychologically, users perceived an increased in safety, function, and ease to perform tasks, which then translates in more independence. These benefits may be the reason why assistive devices are popular among individuals with difficulty walking.

Table 1: Benefits of using a walking aid

Study	**n**	**Sample Characteristics**	**Type**	**Assistive aid**	**Task**	**Benefits**	**PEDro Scale**
Aminzadeh et al. (1998)[29]	30	-% males: 30 -Mean age:72.2	Focus Group	Cane	ADL	-Improve safety -Improve function -Pain reduction -Fall prevention	-
Haggblom-Kronlof et al, (2007)[2]	201	- Healthy -% males: 37 -Age: 76 - 86	Survey	4LW 4WW Cane Crutches	ADL	- Improve safety - Ease to perform tasks	-

Vogt et al. (2010)[23]	60	-geriatric impatience rehabilitation -% males: 24 -Mean age: 78	quasi-experimental pre- and post-design	4WW	TUG FTSST POMA-B	-Improve balance -Improve mobility	4
Trudeau et al (2003)[24]	6	-Alzheimer's patients -% males: 83 -Mean age:79	Pilot study with a cross-over design Follow-up: 2weeks	Merry Walker	Walking	-Improved walking time from 11.72 min to 268.55 min	5
Graafmans et al (2003)[30]	710	-residential care residents -% males: 19 -Mean age:82.8	CSA	Cane Walker	Walking	- Protect from fall in individuals with an intermediate level of physical activity	4
Hoenig et al. (2003)[31]	2368	- Age: 65+ -% males: 28 -% age > 85: 30%	CSA	Varied	ADL	-Less need for personal assistance -More independence	4
Kloos et al. (2012)[32]	21	-Huntington disease patients -% males: - -Mean Age: 49.3 -Non-user prior to study	CSA	Unassisted 4WW 3WW 2WW Standard	Walking	-4WW had less stumble during figure 8 test than walking with no aid.	5

Wolfe et al. (2004)[33]	65	- participants could not walk independently -high risk for falling -% males: - -Mean Age: -	CSA	Walking	WalkAbout	-17 users who could not walk with any other aid were able to walk with the WalkAbout.	4

Legend: CSA = Cross-sectional analysis, ADL = Activities of daily living, WW = wheeled walker, 2WW = 2 wheeled walker, 3WW = 3 wheeled walker, 4WW = 4 wheeled walker, 4LW = 4 legs walker, TUG = time up and go, FTSST = five times sit to stand, POMA-B = performance oriented mobility assessment.

Table 2 highlights several demands, risks, and barriers that users have to face while using an assistive device. The major risk for users is falling. Falls can happen by tripping on the device, which interferes with lower limb movement and also reduces the ability for upper limbs to reach for safety. In addition, misuse of the device is common among users. Barriers can be physical, such as obstacles or sloped ground, or psychological, such as embarrassment or fear. Lastly, physical demands include effort in using the device. These negative aspects of walking aids can lead the user to abandon the device, suffer injuries, or remain dependent on others.

Table 2: Demands, risk, and barriers of using a walking aid

Study	n	Sample Characteristics	Type	Assistive Aid	Task	Risks / Demands / Barriers	PEDro Scale
Bateni et al, (2004)[34]	10	-Healthy -% males: 50 -Mean age:23	CSA	4LW	Standing/ balance	-Risks: -Walker interferes with compensatory lateral stepping. - 60% of steeping reaction collided with the walker. -Reduced average lateral step.	3
Bateni et al, (2004)[35]	16	-Healthy -% males: 50 -Mean age:27	CSA	Cane	Standing/ balance	-Risks: -When holding an object in the hand, grasping for handrails (safety) was significantly decreased.	3
Kallin et al, (2004)[36]	199	-% males: 30 -Mean age: 82.4	Prospective cohort study	4WW	Varied	-Risks: -8 residents fell due to misuse of walkers. -15 falls total.	3
Stevens et al, (2009)[6]	3932	-Healthy -% males: 19 -Age: 65 +	Observational	4WW	Varied	-Risks: -47,312 estimated falls injuries associated with walking aids. 87.3% with walkers. -Rate of fall per 100,000: 59.6 for men and 153 for women.	3

Liu et al, (2009)[37]	13	-Mean age: 83.23 -% males: 0	CSA	4WW	Walking	-Risks: -Users with forward leaning posture during ambulation had higher fall incident rate.	3
Liu et al, (2009)[12]	42	- Assisted living residents -% males: 5 -Age: 85.5	CSA	2WW, 3WW, 4WW	Varied	-Risks: - Significant difference in forward leaning posture between fallers and non-fallers. -Inappropriate walker use: Lack of medical consultation Incorrect walker height Forward leaning posture.	5
Holder et al, (1993)[38]	9	- Healthy -% males: 0 -Age: 29.1	CSA	Unassisted WW	Walking	-Demands: -Vo2, HR, RPP increase from unassisted walking. -Velocity decreased compare to unassisted walking. -RPE higher in arms, legs, chest, and breathing.	3

Aminzadeh et al, (1998)[29]	30	- Healthy -% males: 30 -Age: 72.2	Focus Group	Cane	Varied	-Barriers: Perception of no need Denial of need Fear of dependence Embarrassment / Pride Lack of feeling of safety Lack of knowledge Cost	-
Haggblom-Kronlof et al, (2007)[2]	201	-- Healthy -% males: 37 -Age: 76 - 86	Survey	4LW 4WW Cane Crutches	Varied	-Barriers: Feeling old Feel of unsafety Impractical Cumbersome Embarrassment	-
Lindemann et al, (2016)[39]	22	-Geriatric rehab clinic patients -% males: 50 -Mean Age: 82	CSA	4WW	Walking	-Barriers: walking uphill and downhill and crossing obstacles	3

Legend: CSA = Cross-sectional analysis, WW = wheeled walker, 2WW = 2 wheeled walker, 3WW = 3 wheeled walker, 4WW = 4 wheeled walker, 4LW = 4 legs walker.

Table 3 shows the previous research on walking aids users' satisfaction. Most studies used the Quebec User Evaluation of Satisfaction with assistive Technology (QUEST) questionnaire. The studies were completed in a variety of countries. Overall satisfaction is high, but some users are concerned about the device's weight, and the effort to use it.

Table 3: Satisfaction when using a walking aid

Study	**n**	**Sample Characteristics**	**Type**	**Assessment Tool**	**Assistive Aid**	**Satisfaction Outcome**	**PEDro Scale**
Brandt et al, (2003)[16]	89	- First time users -% males: 33 -Mean Age: 76 - Denmark -70% use it daily	Follow up study (1 month, 4 months)	QUEST 2.0	4WW	-Baseline: 92% (score above 4 out of 5) -4 Months follow up: 94% (score above 4 out of 5) -Not fully satisfied with: weight comfort effort	3
Samuelsson, Wressle, (2008) [28]	175	-% males: 30 -Mean Age: 74.2 - Sweden -91% use it daily	CSA	QUEST 2.0	4WW	Satisfaction with the device characteristics: 90% (score above 4 out of 5)	3

Hill et al. (2008)[17]	27	-COPD patients -% males: 37 -Mean Age: 69.6 - Canada -59% use it daily	CSA	QUEST 2.0	4WW	-Total Score: 4.5±0.5 out of 5 -Women were less satisfied with weight.	4
Wressle et al. (2004)[40]	139	-% males: 35 -Mean Age: 71 - Sweden -59% use it daily	CSA	QUEST 2.0	Walkers	- Highest score: Safety Ease to use Dimension -Lowest score: Follow up	4
Martins et al. (2016)[41]	96	-% males: 43.7 -Mean Age: 67 - Portugal	CSA	P-PIADS	Walkers, crutches, canes	-Positive impact of assistive technologies. - P-PIADS total score for walkers 0.73 on a scale from -3 to +3.	4

Legend: CSA = Cross-sectional analysis, WW = wheeled walker, 2WW = 2 wheeled walker, 3WW = 3 wheeled walker, 4WW = 4 wheeled walker, 4LW = 4 legs walker. QUEST = Quebec User Evaluation of Satisfaction with assistive Technology. PIADS = Psychosocial Impact of Assistive Devices.

Table 4 summarizes previous research on gait mechanics while using assisted devices. 4 weheels walkers were found to be the fastest assisted device and the easiest to move. Only few studies used elderly participants. Forward leaning of the trunk was reported in few studies, and traslated to increase hip flexion in the only study that used motion capture. Two study found no difference between 4WW and unassisted walking, while study using motion capture found less flexion of the hip and knee.

Table 4: Mechanical difference when using a walking aid

Study	**n**	**Sample Characteristics**	**Type**	**Methods**	**Assistive Aid**	**Gait Outcome**	**PEDro Scale**
Kloos et al. (2012)[32]	21	-Huntington disease patients -% males: - -Mean Age: 49.3 -Non-user prior to study	CSA	GaitRite	Unassisted 4WW 3WW 2WW Standard	-4WW had the highest velocity and greater stride length, and least variability of all aids. -No difference between 4WW and unassisted walking	5
Liu et al. (2009)[7]	158	-Retirement center residents -% males: 5 -Mean Age: 85.4 -Non-user prior to study	CSA	Video camera	4WW	-Forward leaning posture during standing in 40% of participants -Forward leaning posture during ambulation in 50% of participants	4

Alkjaer et al. (2006)[14]	7	-Healthy -% males: 0 -Mean Age: 34.7	CSA	Motion capture	Unassisted 4WW	-No difference in walking speed. -Compared to unassisted walking, 4WW: -Increase hip flexion -Decreased knee and ankle flexion/dorsiflexion -Decreased knee extensor moment by 50% -Decreased ankle plantarflexion and hip abductor moments -Increased angular impulse of hip extensor	3
Jayakaran et al. (2014) [42]	27	-% males: - -Mean Age: 44.7	CSA	GaitRite	Unassisted Cane	-When using the cane for support: all gait variables (wing time, stance time, single limb support time, double limb support time) were found significantly different from walking unassisted.	4
De mettelinge et al. (2015)[43]	43	- Residential care facilities residents -% males: 25 -Mean Age: 83	CSA	GaitRite	Unassisted Walker	-Walkers users walk slower, with smaller step length and cadence.	4

Youndas et al. (2005)[44]	10	-% males: 50 -Mean Age: 24.3 -minimal experience	CSA	Motion capture	Unassisted Crutches Cane WW	-When attempting to offload 50% of body weight from one leg, walker's users had lower stride length, speed, cadence, and step width compared to unassisted walking.	5
Protas et al. (2007)[45]	10	-Healthy -% males: 30 -Mean Age: 74.1	CSA	GaitRite	4WW Unassisted	-Wheeled walker did not differ in gait speed, cadence, or stride length compare to unassisted walking. -In the 5 min walk test, it only differed in VO2. No difference in distance, speed, or ventilation.	3

Legend: CSA = Cross-sectional analysis, WW = wheeled walker, 2WW = 2 wheeled walker, 3WW = 3 wheeled walker, 4WW = 4 wheeled walker, 4LW = 4 legs walker.

In summary, the literature review highlighted both physiological and psychological benefits of assistive aids. These benefits can help the users to regain mobility and independence. Thanks to these benefits, users' overall satisfaction is high, especially in factors such as safety, mobility, and easy to perform tasks. However, assistive devices also come with demands and risks. Barriers are both physical and psychological and the major risk is falling. Although overall satisfaction is high, some of the major concerns users have include weight, comfort, and effort. Finally, assistive device may change the users' gait by influencing both the kinetics and kinematics of walking. Studies in this area are scarce. Most studies focused on spatio-temporal variables using an instrumented walkway, while only one study used a motion capture system. Only few of the studies recruited elderly individuals in need of an assisted device, making the generalization of the results to elderly or diseased populations difficult. Participants characteristics, protocols, and type of assisted devices differed among the studies, making it difficult to draw conclusions.

APPENDIX A: Medical History

Medical History
Participant Information

Name: ____________________ Date of Birth: ________________

Address: ___________________ Phone number: ___________

Email: ____________________

Blood Pressure:_____/______ Heart rate ____________________

Height: _________ Measured weight: __________

Gender:

Ethnicity : Caucasian African American Hispanic Asian
Other

Emergency contact name and number:
____

Family Physician name and number:
____

Please answer the following questions:

I. GENERAL HEALTH

1. Have you been diagnosed with diabetes?
   Yes No
   If "yes", please explain
   ____
2. Have you ever had an oral glucose tolerance test?
   Yes No
   If "yes", please explain
   ____
3. Have you ever been told by a physician that you have Osteoporosis/Osteopenia?
   Yes No
4. Have you ever been told by a physician that you have a heart condition?

Yes No

3. Have you or anyone in your immediate family had a heart attack, stroke, or cardiovascular disease before age 50 yrs? If "yes," please explain.

Yes No

____

5. Have you ever been told by a physician that you have high blood pressure?
   Yes No

6. Have you ever been told by a physician that you have high cholesterol?
   Yes No

7. Have you ever been told by a physician that you have thyroid problems?
   Yes No

8. Have you ever been told by a physician that you have kidney disease?
   Yes No

9. Do you feel angina-like symptoms (pain or pressure in your chest, neck, shoulders, or arms)
   Yes No

10. Do you ever lose your balance because of dizziness?
    Yes No

11. Do you ever lose consciousness?
    Yes No

12. Do you consider most of your days very stressful?
    Yes No

13. Do you consider your eating habits healthy overall?
    Yes No

    (Lower in fats and fried foods, higher in fruits, veggies and grains)

14. Have you had any major surgeries?
    Yes No

    If "yes", please explain:

____

15. Do you consider yourself to be generally healthy?
    Yes **No**

16. Do you currently smoke cigarettes or cigars or chew tobacco?
    Yes **No**

    If "yes", how often and how much:

____

17. Are you a former smoker?
    Yes **No**

    If so, how long has it been since you quit smoking?

    ____

18. Has your weight changed more than 5 pounds in the last 6 months?
    Yes **No**

EARS:

____ hearing difficulty

____ ringing

____ pain

____ discharge

____ other

NOSE:

____ bleeding

____ difficulty smelling

____ nasal congestion

____ sinus problems

____ other

Please explain

____

PULMONARY

____ shortness of breath

____ wheezing

____ asthma

____ chronic cough

____ allergies

____ other

Please
explain____

19. Are there any other health related issues we should know about?

____

Please explain

____

II. MEDICATION/SUPPLEMENTS

1. Please list all of the **prescription medication** you are currently taking.

Medicine name Amount taken per day Months/years on the Medication Reason

a.____

b. ____

c. ____

d. ____

2. Any known drug allergies? Explain

____

3. Have you been on steroid medication in the past?

Yes **No**

If so, please explain in detail

____

4. Please list all of the **over-the-counter medicines or supplements** (including vitamins that you take regularly)

Item name Amount taken per day Months/years on Medication Reason

a. ____

b. ____

c. ____

d.____

III. REPRODUCTIVE STATUS

1. Have you reached menopause? (if NO skip to Section III)
   Yes **No**
2. How long has it been since you reached menopause? ________________
   Yes **No**
3. Do you still have your ovaries? _______
   Yes **No**
   a. If not, how old were you when they were removed? _______.
4. Have you ever been on hormone replacement therapy?
   Yes **No**
   a. If so, are you still taking hormone replacement therapy?
      Yes **No**
   b. If you have previously taken hormone replacement therapy, but have since stopped, when did you stop taking hormone replacement therapy?
      ____
5. Have you ever taken osteoporosis medications?
   Yes **No**

   Which ones and for how long?

____

IV. OSTEOPOROSIS/FRACTURE/BONE HEALTH SECTION

1. Have you ever had a bone scan?
   Yes **No**

If so, what year ____________________

What was the outcome_______________

2. Please provide a list of any bone fractures you have had in the past.

Bone Cause (fall, accident, etc)
Year

_____________ ____

4. Did a doctor tell you that any of these fractures were due to osteoporosis/osteopenia?
Yes No

4. Is your diet low in dairy products?
Yes No

5. Do you take calcium supplements?
Yes No

If so, how much per day? ______________________________

6. In a typical week, how many alcoholic drinks do you consume?
____

7. Do you drink coffee, tea, or cola products routinely?
Yes No

About how much coffee, tea, or cola do you drink on an average day?
____

8. Do you have a heart valve or implant devices such as knee, hip ect.?
Yes No

9. Do you get claustrophobic in small spaces?
Yes No

V. SUN EXPOSURE

1. How many times a week do you spend more than 10 minutes outside?
____

2. How much time do you spend outdoors (minutes) per week?___________________________

3. How much of your outdoor time is spent without sunscreen on (minutes)?______________

4. How much of your outdoor time is spent "fully exposed" (minutes)?____________________
("fully exposed" is defined as uncovered face, arms, and hands)

VI. EXERCISE HABITS

1. How many times per week do you generally exercise?

____

   a. What **type(s) of exercise** do you generally perform? (circle all that apply)

Walking	Running	bicycling
swimming	Weight lifting	aerobics
spinning	tennis	

   Other____

   b. In a typical week, **how may days** do you exercise? (circle)

0-1 time/week	2-3 times week	4-6 times/week	daily

   c. How many **minutes** do you typically exercise per session? (circle)

<15min	15-30min	30-45	>45

   Other_______

   d. What is the typical **level of exertion** during your exercise?

Light	Moderate	Moderate/heavy	Heavy

   e. When you are exercising do you ever feel limited by the following?

	Yes	No	Activity
Breathing	____	____	_________________
Chest arm neck pain	____	____	_________________

Low back pain ____ ____ ________________

Side ache ____ ____ ________________

Leg pain ____ ____ ________________

Foot drop ____ ____ ________________

Other? Please explain ________________________________

VIII. EMPLOYMENT STATUS

1. Full-time employed
2. Part-time employed
3. Retired
4. Not working

Please describe employment status ____

IX. EDUCATION

1. None
2. High School
3. College
4. Masters
5. Ph.D.
6. Other

X. MARITAL STATUS **Single** **Married**

I certify that these answers are accurate and complete

YOUR SIGNATURE ______________________________ DATE

Witness ____ date:

APPENDIX B: PAR-Q

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active everyday. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active. If you are planning to become much more physically active than you are now, start by answering the seven questions below.

If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

Yes No

☐ ☐ **1.** Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

☐ ☐ **2.** Do you feel pain in your chest when you do physical activity?

☐ ☐ **3.** In the past month, have you had chest pain when you were not doing physical activity?

☐ ☐ **4.** Do you lose your balance because of dizziness or do you ever lose consciousness?

☐ ☐ **5.** Do you have a bone or joint problem (e.g., back, knee, or hip) that could be made worse by a change in your physical activity?

☐ ☐ **6.** Is your doctor currently prescribing drugs (e.g., water pills) for your blood pressure or heart condition?

☐ ☐ **7.** Do you know of any other reason why you should not do physical activity?

STOP - If you answered YES to one or more questions:

- Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell our doctor about the PAR-Q and which questions you answered YES.
- You may be able to do any activity you want – as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- Start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- Take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live

  actively. It is also highly recommended that you have your blood pressure evaluated. If you reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- If you are not feeling well because of temporary illness such as a cold or a fever – wait until you feel better; or
- If you are or may be pregnant – talk

  to your doctor before you start becoming more active

Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

I have read, understood, and completed this questionnaire. Any questions I had were answered to my full satisfaction. Name (please print): ______________________

________________ Date: ______________________Signature:

____

Signature of Parent or Guardian (for participants under 18 years of age): ________________

____

Note: This physical activity questionnaire is valid for a maximum of twelve (12) months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

APPENDIX C: Training Questionnaire

Training Questionnaire

Section 1: Before training

This section will ask you to rate how comfortable and safe you feel about the imminent task of walking <u>*before*</u> *having the chance to train. Please answer with a number on a scale from 0 to 10, 0 feeling not comfortable at all, 10 feeling completely comfortable, or 0 feeling not safe at all, 10 feeling extremely safe. Write the number next to each statement on the provided line. Please answer all questions. If you are not sure which answer to select, please choose the one answer that comes closest to describing your ideas. If you have any questions for us, ask us at any time.*

<u>Walking with the traditional walker</u>

- How comfortable do you feel walking with a traditional walker? ______
- How safe do you feel walking with a traditional walker? ______

Comments:

<u>Walking with the KB Balance Trainer</u>

- How comfortable do you feel walking with the KB Balance Trainer? ______
- How safe do you feel walking with the KB Balance Trainer? ______

Comments:

Section 2: After training

This section will ask you to rate how comfortable and safe you feel about the imminent task of walking *after* *you had the chance to train. Please answer with a number on a scale from 0 to 10, 0 feeling not comfortable at all, 10 feeling completely comfortable, or 0 feeling not safe at all, 10 feeling extremely safe. Please answer all questions. If you are not sure which answer to select, please choose the one answer that comes closest to describing your ideas. If you have any questions for us, ask us at any time.*

Walking with the traditional walker

- How comfortable do you feel walking with a traditional walker? ______
- How safe do you feel walking with a traditional walker? ______

Comments:

Walking with the KB Balance Trainer

- How comfortable do you feel walking with the KB Balance Trainer? ______
- How safe do you feel walking with the KB Balance Trainer? ______

Comments:

APPENDIX D: Satisfaction Questionnaire

Assisted Device Satisfaction Questionnaire

Visit 1 - Current Device

Do you currently use an assistive device? **☐ YES** **☐ NO**

If you answer "NO", you have finished; you do not need to fill out anything more on this questionnaire.

If you answered "YES", please complete the remaining sections of the questionnaire at the best of your ability. If you have any questions for us, ask us at any time.

Section 1: Current Device Logistics

This section will ask you about receiving and using your current assistive device. Answer all questions at the best of your ability. If you have any questions for us, ask us at any time.

Type of device used:

How did you obtain the walker/cane?

Has anyone ever shown you how to use your walker/cane? ☐ YES ☐ NO

If you answered "YES", who did show you how to use it?

For how LONG have you been using your walker/cane?

How OFTEN do you use your walker/cane?

For what daily ACTIVITIES do you use your walker/cane?

What are some of the reasons that prevent you from using walker/cane during daily activity?

Section 2: Current Device Satisfaction

*This section will ask your views about your current walking aid. Please read each statement and rate them **1 to 10**, being 1 completely disagree and 10 completely agree. Write the number next to each statement on the provided line. Please answer every question. If you are not sure which answer to select, please choose the one answer that comes closest to describing your ideas. If you have any questions for us, ask us at any time.*

My current walker/cane fits well. ______

My current walker/cane helps me to maintain my balance. ______

My current walker/cane allows me to be more active. ______

My current walker/cane allows me to be more independent. ______

Section 3: Quebec User Evaluation of Satisfaction (QUEST) extract

This section will again focus on your satisfaction with your current assistive aid. For each of the following 8 items, rate your satisfaction with your assistive device by using the following scale from 1 to 5:

1: not satisfy at all

2: not very satisfied

3: more or less satisfied

4: quite satisfied

5: very satisfied

Write the number next to each item on the provided line. If you have any comment, add them below each item. Please answer every question. If you are not sure which answer to select, please choose the one answer that comes closest to describing your ideas. If you have any questions for us, ask us at any time.

Items:

1. The dimension (size, height, length, width) of your assistive device? ______

   Comments:

2. The weight of your assistive device? ______

   Comments:

3. The ease in adjusting (fixing, fastening) the parts of your assistive device? ______

   Comments:

4. How safe and secure your assistive device is? ______

   Comments:

5. The durability (endurance, resistance to wear) of your assistive device? ______

   Comments:

6. How easy it is to use your assistive device? ______

   Comments:

7. How comfortable your assistive device is? ______

   Comments:

8. How effective your assistive device is (the degree to which your device meets your needs)? ______

   Comments:

Below is a list of satisfaction items. Please circle the THREE (3) items that you consider to be the most important to you.

1. Dimension
2. Weight
3. Adjustment
4. Safety
5. Durability
6. Ease to use
7. Comfort
8. Effectiveness

Section 3: Falls

Have you ever fallen in the past year? ☐ YES ☐ NO

If you answered "yes", did you fall while using the walker? ☐ YES ☐ NO

Assisted Device Satisfaction Questionnaire

Visit 2 – Traditional vs KB Balance Trainer

This questionnaire will ask your views about the two walkers you used during this study. Please rate each statement with a number from ***1 to 10****, consider 1 as poor performance and 10 as perfect performance. Write the number next to each statement on the provided line. Please answer every question. If you are not sure which answer to select, please choose the one answer that comes closest to describing your ideas. If you have any questions for us, ask us at any time.*

Section 1: Traditional walker

1. Rate your overall satisfaction level using the traditional walker? ______
2. Rate how well the traditional walker fit. ______
3. Rate your confidence while using the traditional walker. ______
4. Rate your balance while using the traditional walker. ______
5. Rate your posture while using the traditional walker. ______
6. Rate the difficulty in using the traditional walker. ______
7. Rate the difficulty in learning how to use the traditional walker. ______
8. How likely are you to use it in the future. ______

Do you have any recommendations?

Section 2: KB Balance Trainer

1. Rate your overall satisfaction level using the KB Balance Trainer? ______

2. Rate how well the KB Balance Trainer fit. ______

3. Rate your confidence while using the KB Balance Trainer. ______

4. Rate your balance while using the KB Balance Trainer. ______

5. Rate your posture while using the KB Balance Trainer. ______

6. Rate the difficulty in using the KB Balance Trainer. ______

7. Rate the difficulty in learning how to use the KB Balance Trainer. ______

8. How likely are you to use it in the future. ______

9. Do you have any recommendations?

References

1. *2016 American Community Survey 1-year Estimate*. October 12, 2017]; Available from: https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk.
2. Häggblom-Kronlöf, G. and U. Sonn, *Use of assistive devices -- a reality full of contradictions in elderly persons' everyday life.* Disability & Rehabilitation: Assistive Technology, 2007. **2**(6): p. 335-345.
3. Bateni, H. and B.E. Maki, *Assistive devices for balance and mobility: Benefits, demands, and adverse consequences.* Archives of Physical Medicine and Rehabilitation, 2005. **86**(1): p. 134-145.
4. *Physical Activity and Health*. June 4, 2015 October 15, 2017]; Available from: https://www.cdc.gov/physicalactivity/basics/pa-health/index.htm.
5. Cruz, D.M.C., et al., *Assistive Technology Accessibility and Abandonment: Challenges for Occupational Therapists.* The Open Journal of Occupational Therapy, 2016. **4**(1).
6. Stevens, J.A., et al., *Unintentional Fall Injuries Associated with Walkers and Canes in Older Adults Treated in U.S. Emergency Departments.* Journal of the American Geriatrics Society, 2009. **57**(8): p. 1464-1469.
7. Liu, H., *Assessment of rolling walkers used by older adults in senior-living communities.* Geriatrics & Gerontology International, 2009. **9**(2): p. 124-130.
8. Liu, H., et al., *Comparison of gait characteristics between older rolling walker users and older potential walker users.* Archives of Gerontology and Geriatrics, 2009. **48**(3): p. 276-280.
9. Liu, H., et al., *Differences in the Limits of Stability Between Older Rolling Walker Users and Older Single-Tip-Cane Users – A Preliminary Study.* Rehabilitation Nursing, 2015: p. n/a-n/a.
10. Faruqui, S.R. and T. Jaeblon, *Ambulatory assistive devices in orthopaedics: uses and modifications.* The Journal of the American Academy of Orthopaedic Surgeons, 2010. **18**(1): p. 41.
11. *Fall Prevention Facts*. November 2, 2017]; Available from: https://www.ncoa.org/news/resources-for-reporters/get-the-facts/falls-prevention-facts.
12. Hao, L., et al., *Pilot study evaluating fear of falling and falls among older rolling walker users.* International Journal of Therapy & Rehabilitation, 2009. **16**(12): p. 670-677.

13. Walker, J.E. and J. Howland, *Falls and Fear of Falling Among Elderly Persons Living in the Community: Occupational Therapy Interventions.* American Journal of Occupational Therapy, 1991. **45**(2): p. 119-122.
14. Nielsen Linda, H., et al., *Biomechanical analysis of rollator walking.* BioMedical Engineering OnLine, 2006. **5**(1): p. 2.
15. Hao, L., R. Zabel, and V. Prati, *Assessment of dependence on assistive ambulatory devices among older adults: A new tool.* International Journal of Therapy & Rehabilitation, 2007. **14**(9): p. 419-423.
16. Brandt, Å., S. Iwarsson, and A. Stahl, *Satisfaction with rollators among community-living users: A follow-up study*. Vol. 25. 2003. 343-53.
17. Hill, K., et al., *Daily Utility and Satisfaction With Rollators Among Persons With Chronic Obstructive Pulmonary Disease.* Archives of Physical Medicine and Rehabilitation, 2008. **89**(6): p. 1108-1113.
18. Demers, L., et al., *Reliability, validity, and applicability of the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST 2.0) for adults with Multiple Sclerosis*. Vol. 24. 2002. 21-30.
19. Demers, L., et al., *An international content validation of the Quebec User Evaluation of Satisfaction with assistive Technology (QUEST.* Occupational Therapy International, 1999. **6**(3): p. 159-175.
20. Demers, L., R. Weiss-Lambrou, and B. Ska, *Item Analysis of the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST).* Assistive Technology, 2000. **12**(2): p. 96-105.
21. Bradley, S.M. and C.R. Hernandez, *Geriatric assistive devices.* American family physician, 2011. **84**(4): p. 405.
22. Lerner, F.Z., J.W. Board, and C.R. Browning, *Effects of an Obesity-Specific Marker Set on Estimated Muscle and Joint Forces in Walking.* Medicine & Science in Sports & Exercise, 2014. **46**(6): p. 1261-1267.
23. Vogt, L., et al., *Rollator use and functional outcome of geriatric rehabilitation.* Journal of Rehabilitation Research and Development, 2010. **47**(2): p. 151-6.
24. Trudeau, S.A., et al., *Enhanced ambulation and quality of life in advanced alzeimer's disease.* Journal of the American Geriatrics Society, 2003. **51**(3): p. 429-431.
25. Kohn, C.G., et al., *Walking Speed and Health-Related Quality of Life in Multiple Sclerosis.* The Patient - Patient-Centered Outcomes Research, 2014. **7**(1): p. 55-61.
26. Khanittanuphong, P. and S. Tipchatyotin, *Correlation of the gait speed with the quality of life and the quality of life classified according to speed-based community ambulation in Thai stroke survivors.* Neurorehabilitation, 2017. **41**(1): p. 135-141.

27. Castell, M.-V., et al., *Frailty prevalence and slow walking speed in persons age 65 and older: implications for primary care.* BMC family practice, 2013. **14**: p. 86-86.
28. Samuelsson, K. and E. Wressle, *User satisfaction with mobility assistive devices: An important element in the rehabilitation process.* Disability and Rehabilitation, 2008. **30**(7): p. 551-558.
29. Aminzadeh, F. and N. Edwards, *Exploring Seniors' Views on the Use of Assistive Devices in Fall Prevention.* Public Health Nursing, 1998. **15**(4): p. 297-304.
30. Graafmans, W.C., et al., *Daily physical activity and the use of a walking aid in relation to falls in elderly people in a residential care setting.* Z Gerontol Geriat, 2003. **36**(1): p. 23-28.
31. Hoenig, H., D. Taylor, and F. Sloan, *Does assistive technology substitute for personal assistance among the disabled elderly?* American Journal of Public Health, 2003. **93**(2): p. 330-7.
32. Kloos, A.D., et al., *The Impact of Different Types of Assistive Devices on Gait Measures and Safety in Huntington;s Disease (Assistive Device Impact on Gait in Huntington's).* PLoS ONE, 2012. **7**(2): p. e30903.
33. Wolfe, R.R., D. Jordan, and M.L. Wolfe, *The WalkAbout: A new solution for preventing falls in the elderly and disabled.* Archives of Physical Medicine and Rehabilitation, 2004. **85**(12): p. 2067-2069.
34. Bateni, H., et al., *Can use of walkers or canes impede lateral compensatory stepping movements?* Gait & Posture, 2004. **20**(1): p. 74-83.
35. Bateni, H., et al., *Resolving conflicts in task demands during balance recovery: does holding an object inhibit compensatory grasping?* Experimental Brain Research, 2004. **157**(1): p. 49-58.
36. Kallin, K., et al., *Why the elderly fall in residential care facilities, and suggested remedies.* J. Fam. Pract., 2004. **53**(1): p. 41-52.
37. Liu, H., et al., *Comparison of Standing Balance Parameters Between Rolling Walker Users and Potential Rolling Walker Users: A Pilot Study.* Physical & Occupational Therapy in Geriatrics, 2009, Vol.27(4), p.298-309, 2009. **27**(4): p. 298-309.
38. Holder, C.G., E. Haskvitz, and A. Weltman, *The Effects of Assistive Devices on the Oxygen Cost, Cardiovascular Stress, and Perception of Nonweight-bearing Ambulation.* J. Orthop. Sports Phys. Ther., 1993. **18**(4): p. 537-542.
39. Lindemann, U., et al., *Problems of older persons using a wheeled walker.* Aging Clinical and Experimental Research, 2016. **28**(2): p. 215-220.
40. Wressle, E. and K. Samuelsson, *User Satisfaction with Mobility Assistive Devices.* Scandinavian Journal of Occupational Therapy, 2004. **11**(3): p. 143-150.
41. Martins, A.C., et al., *Psychosocial Impact of Assistive Technologies for Mobility and Their Implications for Active Ageing.* Technologies, 2016. **4**(3): p. 28.

42. Jayakaran, P., et al., *Influence of a Walking Aid on Temporal and Spatial Parameters of Gait in Healthy Adults.* PM&R, 2014. **6**(9): p. 796-801.
43. de Mettelinge, T. and D. Cambier, *Understanding the Relationship Between Walking Aids and Falls in Older Adults: A Prospective Cohort Study.* J. Geriatr. Phys. Ther., 2015. **38**(3): p. 127-132.
44. Youdas, J.W., et al., *Partial weight-bearing gait using conventional assistive devices.* Archives of Physical Medicine and Rehabilitation, 2005. **86**(3): p. 394-398.
45. Protas, E.J., M.L. Raines, and S. Tissier, *Comparison of Spatiotemporal and Energy Cost of the Use of 3 Different Walkers and Unassisted Walking in Older Adults.* Archives of Physical Medicine and Rehabilitation, 2007. **88**(6): p. 768-773