Effect of hippotherapy on physiological cost index and walking speed of adolescents with diplegia

Hippotherapy's effect on adolescents with diplegia

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ABSTRACT

Introduction: This research describes the therapeutic impact of hippotherapy on adolescents with cerebral palsy (CP) diplegia using the physiological cost index (PCI) and walking speed as outcome measures.

Method: A single system multiple baseline design across subjects was implemented. Ten adolescents with diplegia were included. Participants had to be able to walk independently or with an assistive device. Adolescents were classified, Gross Motor Functional Classification System levels I to III, and were 12 to 17 years old. PCI and walking speed were measured. Hippotherapy sessions took place once a week over a 12-week period. Each hippotherapy session (conducted by an occupational therapist) lasted 30 minutes. Average baseline measurements were compared with measurements taken before each intervention session and to post-intervention measurements.

Results: One participant's PCI values decreased significantly (p=0.014). Walking speed increased significantly over the course of treatment from the 6th intervention session (Wilcoxon Signed Rank Test, p=0.024 for post intervention). The greatest improvement in walking speed was seen at intervention session 12 (p=0.018).

Conclusion: One participant's PCI decreased and ten participants showed increased walking speeds. Adolescents with diplegia need to adjust to increased growth and their walking ability may regress if therapy is not provided. Hippotherapy supports gross motor functioning and simulates the pelvic movement of normal walking.

Key words: Hippotherapy, adolescents, diplegia, physiological cost index, walking speed.

INTRODUCTION AND LITERATURE REVIEW

Adolescents with cerebral palsy (CP) diplegia present with altered posture and motor control impairments of both legs, with the muscles of the arms and upper body usually less affected (Rosenbaum, 2003; Champagne et al., 2017; Johnston et al., 2004). The combination of increased muscle tone, spasticity and altered posture affect the walking patterns of adolescents with CP diplegia and causes them to walk slower and with greater difficulty than able-bodied adolescents (Champagne et al., 2017; Haak et al., 2009; Johnston et al., 2004). Walking difficulties minimise occupational performance in these adolescents as they find it difficult to move between classrooms and play on the playground. These walking difficulties may become more severe without intervention and or as the adolescents age (Gannotti et al., 2008; Haak et al., 2009; Johnston et al., 2004). Despite the need for intervention focussed on improving walking, adolescents with CP seem to be more motivated to participate in hippotherapy than conventional therapy (Debuse et al., 2009; Engel and MacKinnon, 2007). Occupational therapists can use hippotherapy as an exciting alternate treatment strategy to treat walking difficulties.

The hippotherapy team includes a trained occupational therapist, a side walker, a horse-handler and a well-trained horse (Engel and MacKinnon, 2007; Sterba, 2007). To use hippotherapy, the occupational therapist must be registered with their country's health authority and preferably have completed a post-graduate course in hippotherapy as advised by Equine Assisted Therapy Association of South Africa (EATASA) and the American Hippotherapy Association. Hippotherapy incorporates the movement of a horse in conjunction with other occupational therapy treatment principles (Engel and MacKinnon, 2007) such as neurodevelopment treatment, sensory integration, and neuro-physiological principles to improve performance skills. Hippotherapy has proved to be effective in improving the following performance skills in younger children with CP; balance and postural control, (Bertoti, 1988; Sterba et al., 2002; Zadnikar and Kastrin, 2011) weight bearing, (Bertoti, 1991) trunk coordination, walking, (Champagne et al., 2017) and gross motor functioning (Casady and Nichols-Larsen, 2004; Kwon et al., 2015; Sterba, 2007; Whalen and Case-Smith, 2012).

The multidimensional movement of the horse's pelvis generates similar pelvic movements in the client, which mimics the pelvic movement that occurs during normal human walking (Champagne et al., 2017; Engel and MacKinnon, 2007; Rigby, 2009; Sterba, 2007). The constant movement of the horse continuously challenges postural control (Champagne et al., 2017) and the client must employ their trunk muscles to stay seated on the horse. The therapist can increase or decrease the postural challenge by altering the movement and direction of the horse (Engel and MacKinnon, 2007). The premise of hippotherapy is that by improving performance skills (such as balance and trunk control) the client develops better proximal control making it easier to control distal extremities such as arms and legs. If the client has greater control over their extremities, they will use less energy to walk and will walk with greater efficiency and speed. Physiological cost index (PCI) and walking speed are commonly used outcome measures to identify changes in walking in able-bodied individuals and individuals with CP (Graham et al. 2005; McGibbon et al., 1998; Raja et al., 2007) and negates the need for expensive equipment for assessments (Raja et al., 2007).

Previous evidence supports an improvement in walking in younger children (four to twelve years) with CP who received hippotherapy (McGibbon et al., 1998; Sterba, 2007). The effect of hippotherapy on walking in adolscents with CP diplegia has not been determined in previous studies. This article describes the therapeutic effect of hippotherapy on PCI and walking speed in adolescents with CP diplegia.

Objectives

The objectives of this study were to:

i. Determine the effect of 12 hippotherapy sessions on PCI.

ii. Determine whether hippotherapy improves walking speed over a distance of 60 m.

METHOD

Study design

A single system multiple baseline design (Backman et al., 1997) with participants functioning as their own control group was used. The study consisted of a baseline phase and a 12 week intervention phase. Following suggestions that there should be variation in the length of the baseline between participants (Backman et al., 1997), the length of each participant's baseline was randomly allocated and varied between three and nine weeks. Change in performance measures which occurs only at the time that the intervention is introduced indicates a strong relation between intervention and the outcome (Backman et al., 1997; Graham et al., 2012). During the baseline phase participants' resting and walking heart rates and walking speed were measured weekly to establish a baseline PCI and an average walking speed for each participant. During the intervention phase, walking heart rate, resting heart rate and walking speed were measured in the same manner as during the baseline phase. The measurements were taken at the stable yard directly before and after the intervention sessions.

Participants

Fourteen participants were recruited through target sampling at the only two government funded schools for learners with CP in Pretoria, South Africa. Minimum inclusion criteria were; a medical diagnosis of diplegia, passive hip abduction greater than 20 degrees bilaterally as measured with a goniometer in the supine position and the ability to walk, independently or with any assistive device. Participants were excluded if they had hip subluxation confirmed by a medical practitioner, had one or more seizures during the past year; had known osteoporosis, allergies to horse hair or dust or were heavier than 65 kg. The weight limit implemented was due to safety considerations for the participants, side-walker and occupational therapist-researcher (author) should an emergency dismount have been necessary.

Written informed consent was obtained from parents or guardians and written assent from the participants. Ethical clearance was obtained from the Faculty Ethics Committee, Faculty of Health Sciences of the University of Pretoria. Certificate number, 539/2013. The necessary permission was obtained from the Department of Education and from the principals of the two schools.

Of the 14 participants who initially consented to participate; four were withdrawn from the study due to transport and medical reasons. The ten participants, who completed the intervention, ranged between the ages of 12 and 17-years. Five of the participants were able to walk independently and five of the participants walked with hand held assistive devices.

Procedures

Baseline data were collected by the author at the participants' schools. Baseline data included resting heart rate, walking heart rate and walking speed. Heart rates were recorded with a Polar RCX5 Heart Rate Monitor. The transmitter belt was placed on the participant's chest and the wrist watch receiver was placed on an independent observer's wrist. Walking speed was measured by a two independent observers. The independent observers were used to eliminate observer bias. To obtain the resting heart rate, the participants were asked to sit quietly for 15 minutes before a reading was taken. The average heart rate of the last 5 minutes of the 15-minute rest period was recorded as the resting heart rate. To measure the walking heart rate, participants were asked to walk for three minutes to allow for cardio-vascular adaptation to take place. Each participant was then asked to walk over a level 30 m distance, turn and walk back over the same 30 m. The average walking heart rate over the second 30 m distance was recorded as the walking heart rate. Walking speed was calculated over both 30 m distances excluding the turn. To ensure reliability, participants walked in the same corridor at their school each time. Each participant was measured once a week over a number of weeks. The specified number of weeks included in the baseline differed for each participant as prescribed by the multiple baseline design.

Each participant entered the intervention phase once all their baseline data had been collected. The author and an independent physiotherapist (both trained in hippotherapy) matched each participant to a horse most suited to them in terms of size and movement provided by the horse. A tailor-made intervention plan was compiled for each participant to address their specific performance skill impairments. Each participant was invited to attend 12, 30 minute sessions of hippotherapy at a stable yard away from the schools. Extraneous variables typical to a normal therapy setting, such as rain and illness, influenced the regularity of the intervention sessions. Despite the disruptions, each participant completed 12 hippotherapy sessions.

As a precaution each participant's heart rate was measured throughout the intervention session to ensure that the maximum heart rate, calculated with Karvonen's formula (Haff and Triplett, 2016), was not exceeded. Post intervention measurements were taken one week after each participant's last intervention session.

Measurement outcomes

The author investigated the effect of using a hippotherapy treatment strategy on PCI and walking speed with adolescents with CP diplegia (Bailey and Ratcliffe, 1995; Du Plessis, 2016; McGibbon et al., 1998; Raja et al., 2007).

PCI is valid (Plasschaert et al., 2011) and reliable (Bailey and Ratcliffe, 1995; Graham et al., 2005; Raj et al., 2014; Raja et al., 2007) in measuring change in walking in both able-bodied individuals and individuals with CP (Graham et al., 2005; McGibbon et al., 1998; Raja et al., 2007). It also negates the need for expensive equipment (Raja et al., 2007). Yet studies on PCI and CP were mainly conducted on persons within Level I and Level II of the Gross Motor Function Classification System (GMFCS) (Bratteby Tollerz et al., 2011; Raja et al., 2007; Rose et al., 1989). This study included adolescents on Level III.

PCI is calculated as follows;

$$PCI\left(\frac{beats}{m}\right) = \frac{\left(Walking\ heart\ rate\left(\frac{beats}{min}\right) - Resting\ heart\ rate\left(\frac{beats}{min}\right)\right)}{Walking\ speed\ \left(\frac{m}{min}\right)}$$

Walking speed can also be used as an outcome measure of walking (Pasparakis and Darras, 2009; Perry and Burnfield, 2010; Raj et al., 2014). Measuring walking speed can provide valuable information on the effect of hippotherapy. Therefore walking speed data were analysed separately from the PCI data.

Data analysis

Firstly the relationship between the hippotherapy intervention (independent variable) and PCI and walking speed (response variables) were described with mixed effects regression models, using piecewise linear regression on each participant's data. This was done by comparing the trends in baseline measurements to the trends in the measurements taken before each intervention session. This analysis was used because independent variables are partitioned into intervals (baseline phase and intervention phase) and a separate line segment to fit to each interval (Malash and El-Khaiary, 2010).

Secondly the baseline average was compared to the post-intervention measurements for each participant. The Wilcoxon Signed Rank Test is a non-parametric hypothesis test used to compare two paired groups to assess whether their population mean ranks differ. This test was used to test if PCI and walking speed differed between the baseline average, and the post-intervention measurements for each participant as seen in Figure 1 and Figure 2.

Lastly the Wilcoxon Signed Rank Test was used on the collective data from each intervention session and compared to the average collective baseline as seen in Table 1.

RESULTS

Hippotherapy and PCI

A reduction in PCI between baseline and intervention indicates a positive outcome. A mixed-effects regression test, using piecewise linear regression, verified trend changes between all the baseline sessions and all the intervention sessions for each participant. Participant 8 had a significant decrease in PCI values throughout the intervention phase (p=0.014), suggesting that hippotherapy had a positive influence on the PCI of one participant, GMFCS II.

We assessed the effects of hippotherapy on PCI by comparing average baseline PCI to post-intervention PCI measurements (Fig. 1). PCI decreased for four participants (i.e. participants 5, 8, 9 and 12). Of these four, three were classified as GMFCS III and one as GMFCS II. PCI increased for five participants (i.e. participants 1, 3, 4, 10 and 13). Three of these participants were classified GMFCS II and two GMFCS III. PCI remained unaffected for Participant 11, who was classified as a GMFCS I.

When the average combined responses of all the intervention sessions, across participants were plotted, PCI visually decreased. But the Wilcoxon Signed Rank Test demonstrated no significant effect of hippotherapy on PCI (Table I).

Hippotherapy and walking speed

An increase in walking speed (m/min) indicates a positive outcome. The piecewise linear regression demonstrated a significant increase for participant 4 (p=0.015), participant 8 (p=0.000), participant 11 (p=0.003) and participant 13 (p=0.000). Walking speed visually increased for participant 5 (p=0.646) and participant 9 (p=0.051) but did not show statistically significant changes.

Walking speed increased significantly between average baseline measurements and post-intervention measurements (Fig. 2). For seven participants (i.e. participants 4, 5, 8, 9, 11, 12 and 13) walking speed increased. Four of these participants was classified as GMFCS III, two as GMFCS II and one as GMFCS I. Participant 1 (GMFCS II) and Participant 3 (GMFCS I) were unaffected and Participant 10 (GMFCS III) showed a decrease in walking speed.

When compared to the average baseline measurements a statistically significant increase was seen in the average walking speeds for all participants in intervention sessions 6, 7, 12 and in the post-intervention session (Fig. 3 and Table 1).

DISCUSSION

The objectives of the study were to study the effects of hippotherapy on PCI and walking speed of adolescents with CP diplegia over 12 sessions. The results were inconclusive for the combined PCI evidence for all participants. Yet, a reduction in PCI was noted for four participants in our study, which indicates a reduction in heart rate per meter walked. This reduction was statistically significant for one participant suggesting that hippotherapy might influence PCI in some adolescents. Hippotherapy had a positive effect on walking speed from session six onwards. Seven participants showed an increase in walking speed when the baseline average was compared to post intervention measurements. Adolescents with CP diplegia who still need intervention (Debuse et al., 2009), might benefit from hippotherapy.

In a similar study on younger children, McGibbon et al. (1998) reported improvements in PCI and Gross Motor Functional Measure (GMFM) scores in response to hippotherapy. Their study assessed PCI twice pre-intervention and once after the intervention. In contrast to our study that assessed the participants several times during the baseline and intervention phases and once after the intervention. Their study resulted in less cardiovascular activity over the course of their study compared to ours. Another study on younger children, conducted in Canada, (Champagne et al., 2017) found significant improvements compared to baseline levels. The fact that the participants in our study were older and were required to walk repetitively during testing in the intervention phase may have influenced our study outcome.

Most PCI-studies have been conducted on individuals with CP who are minimally to moderately affected (Bratteby Tollerz et al., 2011; Raja et al., 2007; Rose et al., 1989). In Rose's (Rose et al., 1989) comparative study the participants; children with CP, fell within Level I and Level II of the GMFCS. PCI also seems to be a more reliable measure of walking efficiency if a steady state-condition is reached. Our study had five participants who were more severely affected (GMFCS level III) which may have affected their ability to reach a steady-state condition (Boyd et al., 1999). We included individuals on GMFCS level III that might have contributed to inconclusive PCI results. Measuring PCI as an outcome for adolescents who are GMFCS level III, IV and V still needs further investigation.

As functional walking incorporates coordination between many aspects such as balance, muscle movement (Champagne et al., 2017; Johnston et al., 2004), postural stability (Champagne et al., 2017), stride length (Johnston et al., 2004) and the sensation of walking (Engel and MacKinnon, 2007), changes in any of these aspects affects walking speed (Haak et al., 2009). Changes in walking speed after hippotherapy can be attributed to various kinematic interactions with the horse such as improvement in core muscle stability and postural stability (Casady and Nichols-Larsen, 2004). Champagne et al. (2017) also found improvement in standing, walking, running and jumping as measured by the GMFM-88 after a 10 week period of hippotherapy.

LIMITATIONS

Our research shows therapeutic benefits from hippotherapy. The main limit in this study is the small number of participants, which prevents the generalizability of the results. A larger sample size would add statistical power to the conclusions. Much individual variability confounded observations and a baseline GMFM may have been useful to account for gross motor functioning of participants in addition to the GMFCS levels that were available.

Future studies should include detailed evaluation of movement patterns before and after intervention to determine the exact effect of hippotherapy on walking. The effect of hippotherapy on the motivation of adolescents to participate in therapy that improves walking could also be included in future studies.

CONCLUSIONS

Adolescents with CP face substantial challenges as they age (Haak et al., 2009). Growth resulting in extra height and weight cause changes in movement and requires extra therapy to assist adaptation. Children and adolescents with diplegia often experience a decrease in walking speed as they grow (Gannotti et al., 2008; Haak et al., 2009) and effective therapy that is enjoyable and meaningful to them will be benefitial in the long run. Whilst difficult to separate the effect of hippotherapy and the walking assessments, our study does show a therapeutic improvement.

This study provides the foundation for future research, highlighting the need for using appropriate outcome measures. We advocate that hippotherapy in a natural setting provides important experiential benefits that can only be quantified by more rigorous studies in this field.

KEY FINDINGS

- One participant's PCI values decreased significantly.
- Walking speed increased significantly from the 6th intervention session.
- The greatest improvement in walking speed was seen at hippotherapy session 12.

WHAT THIS STUDY ADDS

This study showed that adolescents with CP diplegia can benefit from hippotherapy with regards to walking speed and was the first occupational therapy research in South Africa on hippotherapy.

RESEARCH ETHICS

Ethical approval was obtained from the Faculty of Health Sciences Research Ethics Committee of the University of Pretoria in 2013. Certificate number 539/2013. Permission was obtained from the Gauteng Province, Department of Education (reference number D2014/209) to conduct the study.

CONSENT

The parents/guardians of all participants provided written informed consent for their child to take part in the study. This included the placement of a heart rate monitor, the measurement of all relevant aspects such as walking speed, and to be recorded on video. This was done after an individual information session was held with each participant and their parents. Each participant gave written assent to the same procedures as mentioned above.

DECLARATION OF CONFLICTING INTERESTS

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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CONTRIBUTORSHIP

Ninette du Plessis was the researcher and main contributor to the study in fulfilment of her Masters' degree in Occupational Therapy at the Faculty of Health Sciences of the University of Pretoria. Ninette du Plessis, guided by her supervisors, applied for, and obtained, ethical approval from the Faculty of Health Sciences at the University of Pretoria, Tania Buys, the postgraduate supervisor, and Jodie de Bruyn, the co-supervisor, contributed substantially to the research process by advising, revising and editing of the research proposal and dissertation. Ninette du Plessis and Jodie de Bruyn interpreted the statistical data.

All authors reviewed, edited and contributed to the manuscript and approved the final version. All the authors have read and approved the manuscript for submission and publication. No contributors who qualify for authorship have been omitted.

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Ms Danielle C Booysen of Munro Consulting Actuaries, applied the Wilcoxon Signed Rank test on how PCI and walking speed differed between the average baseline session, each intervention session and post-intervention session.

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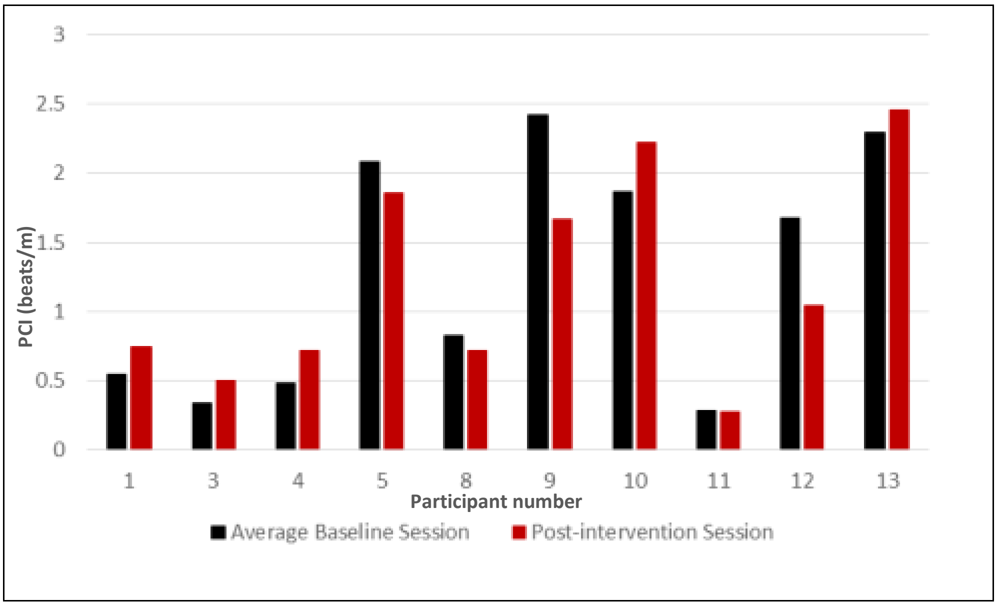

Figure 1: Change in PCI (beats/m) for each participant before and after 12 sessions of hippotherapy .

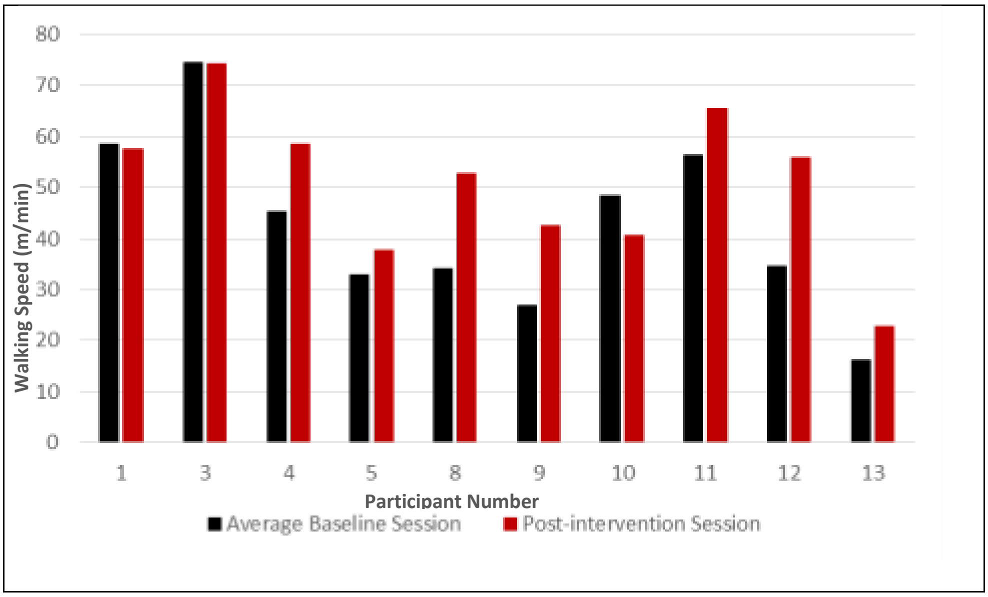

Figure 2: Changes in walking speed (m/min) for each participant before and after 12 sessions of hippotherapy

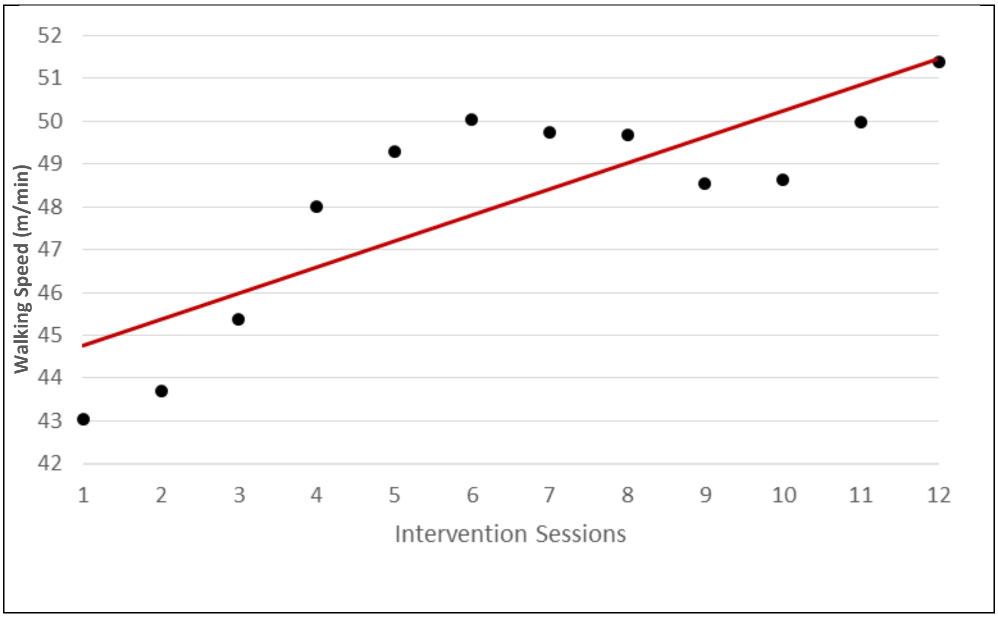

Figure 3: Walking speed (m/min) per intervention session

P-Values		
	Walking speed	**PCI**
Intervention session 1	0.500	0.839
Intervention session 2	0.348	0.784
Intervention session 3	0.216	0.216
Intervention session 4	0.065	0.935
Intervention session 5	0.065	0.539
Intervention session 6	**0.042**	0.539
Intervention session 7	**0.024**	0.903
Intervention session 8	0.065	0.652
Intervention session 9	0.065	0.754
Intervention session 10	0.116	0.958
Intervention session 11	0.116	0.652
Intervention session 12	**0.019**	0.161
Post-Intervention session	**0.024**	0.500

Table I: The Wilcoxon Signed Rank Test per intervention session