Published in final edited form as:

J Addict Dis. 2010 October ; 29(4): 481–492. doi:10.1080/10550887.2010.509275.

Injection-Related Venous Disease and Walking Mobility

Barbara Pieper, PhD, APRN, BC, FAAN [Professor/Nurse Practitioner],

College of Nursing Wayne State University 5557 Cass Avenue Detroit, MI 48202 Phone: 313-577-4057 Fax: 313-577-4188 bpieper@wayne.edu

Thomas N. Templin, PhD [Professor],

Center for Health Research College of Nursing Wayne State University 5557 Cass Avenue Detroit, MI 48202 Phone: 313-577-7992 Fax: 313-577-5777 t.templin@wayne.edu

Robert S. Kirsner, MD, PhD [Professor and Vice-Chairman], and

Department of Dermatology & Cutaneous Surgery University of Miami Miller School of Medicine 1600 N.W. 10th Avenue, RMSB, Room 2023-A Miami, Florida 33136 Phone: 305-243-4472 Fax: 305-243-6191 rkirsner@med.miami.edu

Thomas J. Birk, PhD, MPT, FACSM [Associate Professor and Chair]

Department of Health Care Sciences Eugene Applebaum College of Pharmacy and Health Sciences Wayne State University 259 Mack Avenue Detroit, MI 48201 Phone: 313-577-1368 Fax: 313-577-8685 ae7647@wayne.edu

Abstract

Injection users are at risk for vascular injuries resulting in chronic venous disease (CVD). We examined walking mobility in relation to CVD for 713 persons in methadone treatment. We used a cross-sectional, comparative design, stratified on age, sex, ethnicity, and drug use. CVD was present in 92.3% of participants. The structural equation model supported the causal link between leg injection and CVD (.40, $P < .001$). The worse the mobility, the greater was the CVD classification (-.21, $P < .001$). CVD had an indirect effect on mobility through pain. CVD and pain need to be considered when assessing mobility in illicit drug users.

Keywords

Injection drug use; Chronic venous disease; Walking mobility; Leg pain

INTRODUCTION

Among the many unintended consequences of injection drug use, problems with the legs due to injection-related venous disease have received little research attention.^{1,2} We found a high prevalence (87% and greater) of venous disease in methadone maintained adults.^{1,3} Injection-related venous disease is a vascular condition of the legs that results from trauma of repeated injection, irritating qualities of the abused drugs and substances, and localized infections. Pathophysiologic changes occur to the venous system, as well as to the joints and muscles of the lower leg occur. These venous changes are medically classified as chronic venous disease (CVD). The clinical manifestations of venous disease include pain, making mobility difficult. Our current research investigates the relationship between walking mobility and injected-related chronic venous disease in methadone maintained adults.

Walking mobility, which includes balance, gait, and walk speed, affects a person's performance of daily functioning. Essential to maintenance of physical autonomy⁴, balance, gait and walk speed have been studied in the elderly⁵⁻⁷ and are negatively impacted by chronic illnesses such

as diabetes mellitus⁸ and stroke⁹. These dynamic activities of walking mobility are infrequently examined in illicit drug users. Although venous and leg muscle/joint damage have long been identified as risk factors for CVD, little is known about the impact of mobility impairments on the etiology of venous disease. We therefore examined the bidirectional relationship between walking mobility and injection-related chronic venous disease for persons in methadone maintenance treatment.

Chronic Venous Disease

Chronic venous disease represents a spectrum of leg changes, often devastating, that affects large numbers of persons who injected drugs in the lower extremities.¹ Unfortunately, injecting in the groin, legs, and feet has been reported to occur as the veins in the arms and upper body become difficult sites for injection¹⁰; lower extremity injecting accounted for about 50% of the injecting years.³ Injecting practices, as well as drugs/contaminates injected, traumatize and destroy the veins in general and venous valves specifically. The impaired venous circulation in the legs disrupts the microcirculation of the skin and supporting tissue, making the legs susceptible to ulcers that are painful, difficult to heal, and recurrent.

Although venous disease is most commonly seen in older adults because of vein changes that occur across the lifespan, injection users develop venous disease at a young age as they have injection-related venous trauma that often begins in the late teens.¹¹ The venous damage evolves and worsen over time even after the person stops injecting. In our study of 204 persons who used injected drugs (85.3% leg injectors), the point prevalence of CVD was 87% with 52% being in the most advanced stages.³ Manifestations of venous disease include varicosities, edema, hyperpigmentation, lipodermatosclerosis, pain, and ulcers.¹² The impact of venous ulcers on injection users has been described as crippling pain, reduced walking, standing and stair climbing, and social isolation.¹³⁻¹⁷ Ankle mobility crucial for ambulation is decreased.¹⁸ Thus, the overall negativity of venous disease has the potential to impair balance, gait, and walk speed. Conversely, the pathophysiology of venous disease suggests that reduced lower limb activity will negatively impact venous circulation and contribute to increased severity of disease.

We, therefore, hypothesized a bidirectional relationship between injection-related chronic venous disease and walking mobility in which (a) chronic venous disease affects walking mobility through leg pain, and (b) leg pain affects chronic venous disease through walking mobility. These three variables, leg pain, chronic venous disease, and walking mobility, are expected to form a negative feedback loop in which each variable acts as a mediator for the other two. Our specific aims were to: (a) describe balance, gait, and walk speed for persons in methadone treatment; (b) examine a walking mobility construct comprised of balance, gait and walk speed; and (c) test a model of injection-related venous disease.

METHODS

Design

The study's design was previously described.¹ Participants (N = 713) were recruited from 12 methadone treatment clinics located in a large urban area between 2005 and 2007. Eligible participants were 25 to 65 years of age, able to understand and speak English, without lower extremity amputation, able to walk, non-pregnant, and physically and mentally able to participate. The study used a three-group, cross-sectional, comparative design with stratification. The three groups were determined by site of injection/non-injection drug use: *Group 1* consisted of non-injection drug users; *Group 2* consisted of participants who injected drugs in their arms and/or upper body only; and *Group 3* consisted of participants with a history of injecting in their legs (leg +/- arm). We enrolled participants into the three groups in a 1:1:2

distribution, respectively. The primary comparison group (Group 3) was sampled at twice the rate of the other groups. Stratification within each drug group was based on age (25 – 39 years; 40 – 49 years; 50 – 65 years); gender (male, female); and ethnicity (African American; White).

Data collection

The research nurse and physical therapist obtained informed consent from all participants and collected all data. Questionnaires were read to participants. Participants were weighed and measured to determine body mass index and the legs were assessed for clinical manifestations of venous disease. The Tinetti Balance and Gait test and walk speed testing were performed. Participants delayed their methadone dose until after completion of the study. Participation in the study took 1 ½ to 2 hours; participants were compensated \$40 for their time. The study was approved by the Institutional Review Board of the affiliated university.

MEASURES

Demographic and Health

The Demographic Questionnaire provided information about sex, race, and age of participants. The Health History Questionnaire was a self-report of 23 medical diagnoses. For the body mass index (BMI) calculation, participants were measured and weighed on a standard scale. In this study, the test-retest reliability values for the Demographic and Health History Questionnaires were .99 and .86, respectively.¹⁹

Leg Pain

The Pain Severity subscore of the *Brief Pain Inventory (BPI) Short Form*²⁰ was modified to focus on the legs. Participants rated their leg pain for worst, average, and now pain. The items were scored on an 11-point scale from 0 (*no pain*) to 10 (*worst possible pain*). Pain severity is a primary factor that determines the impact of pain on the person.²¹ The items were combined for a total pain score. The pain severity items have a reported Cronbach's alpha of .85.²² The Cronbach's alpha for the three pain severity items for this study was .89.

Drug History and Site of Injecting

A Drug History Questionnaire was used to obtain a detailed drug history about illicit drugs consumed orally, smoked/inhaled, and/or injected.²³ For each substance, the participant reported if ever used, age at first use, age at last use, and the number of years between first and last use that the substance was not used. Additional questions addressed the number of years of injecting in the upper body (i.e., hands, arms, and above the waist) and the number of years injecting in the lower body (i.e., groin, legs, and feet). Years of use for each substance and route of use were calculated by: [(age last used – age first used) – years never used]. The Drug History Questionnaire had a median kappa value of .79.²³

Balance and Gait

The Tinetti test was used to assess balance and gait. For the balance, the participant sat in a hard, armless chair. The following Tinetti balance items were assessed: sitting balance; arise with or without using arms from the chair; attempts to stand; immediate standing balance; standing balance; nudged with examiner lightly pushing on subject's sternum; balance with closed eyes for 15 seconds; turning 360 degrees while examining step pattern and steadiness; and sitting down.²⁴ Each item was scored 0 to 1 (4 items) or 0 to 2 (6 items). Zero represented unable to do, unsteady, or unsafe whereas 1 represented steady or able to do to some degree and 2 demonstrated the best degree. Total balance scores range from 0 to 16. Kopke and Meyer²⁵ found that the balance scale used in 10 of 23 articles was the 0-16 scale. We reported

a test-retest reliability of $r = .86$ for the balance score and an internal consistency Cronbach's $\alpha = .79$ for Balance at Time 1 and $.78$ at Time 2.¹⁹

For the gait portion of the Tinetti, the participant walked a total of 6-meters at their usual pace. The participant was evaluated on initiation of gait, step length and height, step symmetry, step continuity, path, trunk sway, and walking stance.²⁴ Eight items were scored 0 to 1, with 1 the stronger or better score; two items were rated 0 to 2 with 2 as the best score. Total gait scores range from 0 to 12. Kopke and Meyer²⁵ found that a gait score based on the 0-12 scale was reported by 6 of 16 publications. We reported a test-retest reliability of $r = .86$ for the gait score and an internal consistency of Cronbach's $\alpha = .84$ for gait at Time 1 and $.86$ at Time 2.¹⁹

The Balance and Gait scores may be summed for a total score with the higher number indicating the better performance. When using the Tinetti to assess fall potential, total scores of 18 or lower are considered *high risk* for falls; scores ranging from 19 - 24 indicate *risk* of falls.²⁴

Walk Speed

Walk speed was determined from a timed walk. The participant walked 3 meters at his/her normal pace and speed, turned around without touching anything, and walked back to the start. The walk test was timed in seconds with a stop watch. Walk speed was calculated by dividing the meters walked (which was always 6 meters) by the number of minutes to complete the task in order to achieve a meters per minute scaling. We reported a test-retest reliability of $r = .79$ for walk speed.²⁴

Chronic Venous Disorders

The clinical portion of the Clinical-Etiology-Anatomy-Pathophysiology (CEAP) Classification provided the severity of the CVD. This descriptive leg assessment was scored as: Class 0 – no visible or palpable signs of venous disease; Class 1 – telangiectasias or reticular veins; Class 2 – varicose veins, distinguished from reticular veins by diameter of 3 mm or more; Class 3 – edema; Class 4a – pigmentation or eczema; Class 4b – lipodermatosclerosis or atrophie blanche; Class 5 – healed venous ulcers; Class 6 – active venous ulcer.²⁶ In our previous work, the inter-rater reliability of the CEAP was kappa = 1.0.³ We determined clinical CEAP inter-rater reliability was .97 for the right leg and .94 for the left leg.¹

Data Analysis

We first performed simple frequencies to describe the participants. The relationship between CVD, leg pain, and walking mobility was examined using correlations and structural equation modeling (SEM).²⁷⁻³⁰ Correlations are an index of the linear relationship between two variables, but do not take into account the direction of the relationship or confounding. Hence, simple correlations will either underestimate or overestimate the true relationship among CVD, leg pain, and walking mobility. Although more complex, structural equation modeling allows for directional effects and control of confounding variables. A structural equation model of the hypothesized structural relations linking CVD severity to leg pain and walking mobility in a continuous feedback loop was fit to the data. This model included age, BMI, and comorbidities as control variables.

RESULTS

Sample

Participants ($N = 713$) were 335 men (46.9%) and 378 women; they ranged in age from 25 to 65 years old ($M = 46.26$, $SD = 9.06$ years). They included 440 (61.7%) who were African American, 64.5% who had a high school or higher education, and 30.0% who were employed

full or part time. Participants reported a mean of 2.91 (SD = 2.15) co-morbid health conditions. Their mean BMI was 28.05 (SD = 6.81).

A quota sampling procedure was used to recruit participants into one of three groups distinguished by site of injection/non-injection drug use: *Group 1* consisted of non-injection drug users (n = 195); *Group 2* consisted of persons who injected drugs in their arms and/or upper body only (n = 178); *Group 3* consisted of persons with a history of injecting in their legs (n = 340). All but 14 (4.1%) of persons in the leg injection group had a history of both arm and leg injection. Those who injected drugs (n = 518) did so for a mean of 13.08 years (SD = 9.77 years). Among those who injected, mean years of injecting in their arms were 9.08 (SD = 8.15 years); mean years injecting in their groin, legs, and/or feet was 9.19 (SD = 8.40 years).

Clinical CEAP

Because the right and left leg distributions of the clinical CEAP were highly similar with a rank order correlation of .93, we classified individuals by the clinical CEAP classification of their worst leg. Using this classification, only 7.7% (n = 55) of the sample did not exhibit clinical changes; 56.8% percent had mild disease (Classes 1 – 3), 18.5% had moderate disease (Classes 4a and 4b), and 17.8% had severe disease (Classes 5 and 6). The most common classification was Class 3, edema without skin changes (24.8%).

Balance, Gait and Walk Speed

Tinetti Balance and Gait scores were negatively skewed toward the high/good end of the scale. With a maximum balance scale score being 16, the mean balance score was 13.85 (SD = 2.40). With the maximum gait score being 12, the mean gait score was 10.93 (SD = 1.73). The mean balance plus gait score was 24.78 (SD = 3.88). Even with these high/good scores, 143 participants (20%) had Tinetti total scores between 19 and 23, indicating “risk of falls” and 55 persons (7.7%) had scores of less than 19 indicating “high risk of falls.” The mean walk time was 39.20 meters/minutes (SD = 10.61). The median time to walk one mile was 40 minutes.

Leg Pain

Mean leg pain scores were the following: worst pain 4.75, (SD = 3.70), average pain 3.56 (SD = 2.91), and now pain 2.67 (SD = 2.85). The overall mean leg pain score was 3.69 (SD = 3.15).

Correlations of Variables Affecting Mobility and Balance, Gait, and Walk Speed

Table 1 shows the correlations among the variables that were used in the causal model of injection-related venous disease. All but two correlations in the table were significant ($P < .05$); each was in the expected direction. Except for the correlation between leg injection drug use, each of the model variables had a correlation of similar magnitude on each measure of Walking Mobility (balance, gait, and walk speed). These variables were negatively related to age, BMI, co-morbidity, leg injection drug use, venous disease, and leg pain.

Model of Injection-related CVD

The structural equation model (SEM) for injection-related venous disease is shown in Figure 1. The model consists of latent variables (e.g., Walking Mobility) and measured variables (e.g., balance, gait, and leg pain). By convention, the latent variables are shown in ovals and the measured variables are shown in rectangles. The predicted structural pathways are shown with thicker lines than the variables included for covariance adjustment. The small unlabeled ovals are residual terms or measurement error. The large oval is the Walking Mobility latent construct defined by the Tinetti Balance and Gait scores and walk speed. The double headed arrow between the error terms on the Balance and Gait scale was added to improve the model fit. All other pathways shown were included in the initial model. This model allows for the statistical

control of co-morbid health conditions and other variables likely to influence the variables in the structural model. Based on prior research³, site-of-injection (Leg vs. Arm/None) was modeled to have a direct effect on CVD and no direct effect on mobility. The variables of age, BMI, and co-morbidity were modeled to have a direct effect on CVD, Leg Pain and Walking Mobility. In this way, the effects of CVD, Leg Pain, and Walking Mobility in the structural loop were controlled for age, BMI, and co-morbidity. The validity of a causal interpretation depends on the inclusion of all relevant confounders in the model. This is a limitation that is acknowledged given that researchers can never be certain that all confounders have been identified.

This model was fit to the variance-covariance matrix of the measured variables using AMOS structural equation modeling software. The path coefficients were estimated using maximum likelihood estimation. The overall fit of this model using conventional criteria was excellent [comparative fit index (CFI) > .98, root mean square error of approximation (RMSEA) = .062, and the ratio of likelihood ratio chi-square to degrees of freedom = 3.7]. Each of the structural path coefficients was significant ($P < .05$). The figure shows the obtained standardized path coefficients (single headed arrows) and correlations (double headed arrows). The significant path coefficients are shown in bold font. Non-significant path coefficients involving the control variables are shown in smaller italic font.

Consistent with prior research, the pathway from injection site to CVD was .40 and significant ($P < .001$), supporting the causal link between leg injection and CVD. The path from Walking Mobility to CVD was -.21 and significant ($P < .001$); the worse the mobility, the greater the CVD classification. Furthermore, the indirect path from CVD to Walking Mobility through Leg Pain was significant [standardized indirect effect = $(.11) * (-.38) = -.04$, $P = .012$], indicating that CVD has an indirect effect on mobility through pain regardless of a person's age, BMI, or number of other health problems.

The standardized path coefficients linking the Walking Mobility factor to Balance (.80), Gait (.73) and Walk Speed (.58) were also significant ($P < .001$) indicating that each variable contributed to defining the construct. This result supports the use of walk speed as one additional performance component in the assessment of Walking Mobility. The error terms for the Balance and Gait scales were allowed to correlate to improve fit. This correlated error is probably due to the fact that the checklists of both scales were filled out by same rater.

DISCUSSION

This methadone treatment based study examined balance, gait, and walk speed as a walking mobility construct and tested a model of injection-related venous disease. We found support for the bidirectional relationship between walking mobility and chronic venous disease for persons in drug treatment. First, walking mobility negatively affected CVD as evidenced by its significant path (-.21). The worse the mobility, the greater was the chronic venous disease classification. Support for this effect of mobility on CVD is evident when examining risk factors and pathophysiologic mechanisms for CVD. First, risk factors for CVD include many conditions that slow mobility such as leg trauma, obesity, rheumatoid arthritis, and age.^{31,32} Environmental and behavioral risk factors include immobility, such as with prolonged standing and a sitting posture at work³³, as the calf muscles rapidly waste and weaken with disuse.³¹ Second, the pathophysiologic mechanism of venous disease includes critical roles for both the calf muscle pump and intact venous valves for emptying of the deep veins in a cephalic direction.^{32,34} The calf muscle pump is important because of its high capacitance, the high pressures it can generate, and its positioning in the lower half of the limb where the venous pressure is maximal.³⁵ The ejection fraction is an indicator of the ejecting ability of the calf muscle. With impaired calf muscle and/or vein valve function, the resulting residual volume

of blood in the calf increases immediately after muscle contraction and causes the ambulatory venous pressure to rise (e.g., venous hypertension).³⁵ Ultimately, the microcirculation of the skin and subcutaneous tissue are affected by venous hypertension. Deterioration of the calf muscle pump function, such as with immobility, has been associated with the clinical class of CVD.³⁵ More than 70% of persons with venous ulcers have impairment of the calf muscle pump.³⁵ In summary, our findings support the importance of mobility and CVD; changes to the musculoskeletal unit of the leg from inactivity can adversely affect the dynamics of the pathophysiologic mechanism of the calf muscle pump.

The reciprocal role of venous disease on mobility through pain was also supported. Early manifestations of CVD, such as pain, burning, heaviness, aching, and edema decrease physical activity and add to calf muscle weakness.³³ Venous ulcers often result in the person reporting long term leg pain. We previously reported leg pain as a mediator of the relationship between CVD and behavioral functioning.¹⁶ To control pain in their legs and feet especially when venous ulcers are present, injection users often do not move their feet or ankle joints while walking. The lack of foot and ankle movement negatively impact lower extremity function needed for mobility. Injection users reported that working, walking outside, standing, and stair climbing increased leg pain thus limiting the person's activity.^{16,36} Heinen and colleagues³⁷ found persons with venous ulcers had low physical activity levels. We previously reported that as the clinical manifestations of CVD worsened, the amount of time spent sitting during work increased and the distance walked per day decreased.¹⁸

We found good evidence for a walking mobility construct that included the Tinetti Balance and Gait scores and walk speed. Balance score indicated 20% of participants had a risk of falls and 7.7% had a *high* risk of falls. Our report of balance and gait testing and walk speed is unique in terms of examining persons with a history of injection drug use. Tinetti balance and gait tests have been used to discriminate between normal and altered mobility performance for the elderly and identify older adults at risk for falls.^{7,38,39} To our knowledge, these tests have not been used to assess a drug treatment population. About a quarter of our participants had abnormal tests, thus adding support to explore balance and gait as part of mobility assessment. Although further research is needed, balance and gait testing of persons in a drug treatment, especially for those who have mobility problems, may help to identify activity protocols that would be helpful. For example, strength and exercise training for the elderly has been reported to be beneficial for mobility, especially in terms of balance.⁴⁰⁻⁴² Lower extremity strengthening contributed to greater ankle force production to balance.⁴³ Task specific exercise programs targeting balance and gait deficits were reported to reduce the number of falls.⁴⁴ Consequently, understanding injection users at risk for mobility impairments may help to target those who would be helped by lower extremity strengthening.

In addition balance and gait measures, we measured walk speed and found it to be very slow. Walk speed tends to decrease with age and is slow in the elderly.⁴⁵ Walk speed is of particular concern in this study because our participants in general were middle-aged ($M = 46$ years). Changes in speed and stability during walking are associated with impaired balance and increased risk of falls in older adults.⁴⁶ Slow walk speed may be a factor in decreasing physical activity in drug users.¹⁸ As activity is lost with slow mobility, muscle mass, which is important for gait, is lost. The posterior lower portion of the leg plays an equally large role in stride during gait.⁶ Thus muscle changes to the legs may affect walking speed, stand balance, and sit to stand performance.⁶ The slow walk speed of our participants has marked implications for the ability to perform physical activities either at home or work. As work opportunities become available to persons in drug treatment, counselors and clinicians need to consider the speed needed for these activities and if the person is capable of performing work activities.

Study Limitations

This study has a few notable limitations. We examined a causal model of the relationship between venous disease and physical activity using observational data. Such models are now common place in social science research and are appearing with more frequency in medical research.⁴⁷⁻⁵⁰ Several untestable assumptions are involved, including the primary one that all relevant causal variables are in the model. We included the variables identified by prior research and allowed each to affect the paths of interest. This is a conservative approach; if non-significant covariate paths were trimmed from the model, the structural paths would increase in size and significance. Of course, there is no way to know that all relevant variables were measured. However, if ordinary regression were used to examine the relations specified in this model, the same assumptions would be needed for interpretation. In addition, at least three separate regressions would be needed: one involving the regression of CVD on leg injection drug use; another involving Walking Mobility and all covariates; and a third involving the regression of leg pain on CVD and covariates. These regressions would be less accurate than the SEM estimated here because the effect of Walking Mobility on CVD in the first regression would include variance attributable to the effect of CVD on Walking Mobility through leg pain. Since ordinary regression entails similar assumptions and results in more biased estimates, SEM is seen as the more appropriate choice.

Other limitations are that mobility can be affected by cognitive factors. We did not specifically measure cognitive function, but excluded potential participants who demonstrated cognitive impairment when the study was explained. Including cognitive tasks during walking would provide more information about mobility. For example, the performance of a cognitive task reduced walking speed in the elderly^{46,51} and was associated with gait and balance impairment.⁵² We did not examine mobility with different levels of complex tasks such as stair use or working. The complexity of a task and performance of secondary tasks were found to affect balance, which in turn impacted gait and walking pattern.^{53,54} Mobility can be influenced by specific diseases such as diabetes mellitus, ocular changes, etc. We did not examine specific disease conditions, but instead the total number of reported co-morbid conditions. Our study included participants across a broad age range (25 to 65 years of age). Since persons in drug treatment are aging (i.e., Baby Boom phenomenon), research is needed specifically about mobility in persons 50 years of age and older. There are many leg problems besides CVD that injection users have that impact risk factors affecting mobility. Nerve and muscle damage from injecting drugs may impair function of the calf muscle and ankle joint.

Implications

How to prevent and/or manage CVD in injection users is important in addiction health for many reasons. In part, this is because of venous disease's negative affects on multiple aspects of life. There are no easy solutions. Education is a crucial component of prevention and management which is accomplishable at multiple levels – patients, clinicians and counselors. One effort at primary prevention of venous disease involves altering the site of drug administration away from the groin, legs, and feet as the primary factor for CVD leg changes was injecting in these sites.¹ Clinicians and counselors, especially in risk reduction programs, can participate in primary prevention in other ways as they educate injection users about safe injection techniques to prevent damaging the veins as much as possible. Unfortunately, there is no way to protect the veins from substances injected in street drug mixtures.

Current and former injection users can also be involved with secondary prevention as they can be taught to monitor for the clinical changes of CVD. Typically, advanced CVD changes are seen in the elderly¹²; but in injection users, these changes often occur in the 40s (i.e., edema, varicose veins, darkening of skin color, itch etc.).¹⁷ Thus, clinicians may inadvertently miss opportunities at early diagnosis. Protection of the legs is critical, such as leg elevation when

sitting and use of compression stockings. Prescription stockings (30-40 mmHg) provide the best compression⁵⁵, but over the counter low pressure (10-15 mmHg) stockings are better than no compression for those who cannot afford the prescription stockings. Treatment clinics can provide extra chairs or foot stools for leg elevation during group sessions. Our research also suggests that deterioration in calf muscle pump function occurs and therefore attempts at strengthening the muscle are worthy.¹⁸ If a venous ulcer develops, injection users need to be encouraged to seek professional wound care. Large ulcer size and long term ulcer duration negatively affect healing.⁵⁶ Healing of the venous ulcer intensifies the education process since 80% of venous ulcers re-occur; thus, leg protection and compression stocking are integral components of care.⁵⁶ In addition, cigarette use should be discouraged because of its effect to decrease arterial flow and negatively affect wound healing.

Leg changes can be painful. In order to decrease leg pain, individuals may walk with a shuffling gait so as to avoid moving the ankle joint. This results in loss of ankle joint movement which negatively affects the calf pump. Gait training and improving ankle range of motion may be helpful as might be medications for the neuropathy that occurs in these patients.⁵⁷ Clinicians should watch clients walk and encourage them to bend the ankle and foot in a normal motion.

Treatment center providers are ideally positioned to help with leg problems since they see these clients so frequently. They can participate in primary and secondary CVD prevention, encourage educational programs about CVD, be alert for clients' complaints about leg changes, and encourage wound care as necessary.

Conclusions

Our model of mobility impacting CVD and CVD impacting mobility through leg pain was supported in this sample of persons in methadone treatment. Injection drug users are at risk for impaired mobility related to CVD. Balance, gait, and walk speed were significant factors for a walking mobility construct. Thus, damage to the legs from injecting drugs has grave implications for mobility. There is an urgent need to understand balance, gait, and walk speed as they impact employment and family functioning for the person in drug treatment. In addition, factors associated with mobility may assist in developing methods to preserve gait, balance, and walk speed as these individuals age.⁵⁸

Acknowledgments

Funding: This project was funded by the National Institute of Nursing Research/National Institute of Health (NINR/NIH), Effect of Drug Use on the Legs: Chronic Venous Insufficiency, Mobility and Pain, R01 NR009264.

The authors gratefully acknowledge Terri Gibbons, BS, Valerie Grech, ADN, RN, and Joyce Peck, BSN, RN as research assistants. The authors acknowledge the invaluable contributions of the following methadone treatment centers: Department of Human Services, Building 5 & Gratiot, Detroit; Metropolitan Rehabilitation Clinics, Oak Park; Millennium Treatment Services, Madison Heights & Warren; Nardin Park Recovery Center, Detroit; New Light Recovery Center, Detroit; Parkview Counseling Centers Detroit, Dearborn Heights, & Pontiac; STAR Center Inc., Detroit; University Psychiatric Centers – Jefferson, Detroit.

REFERENCES

1. Pieper B, Templin TN, Kirsner RS, Birk TJ. Impact of injection drug use on distribution and severity of chronic venous disorders. *Wound Repair Regen* 2009;17(4):485–91. [PubMed: 19614913]
2. Salmon AM, Dwyer R, Jauncey M, van Beek I, Topp L, Maher L. Injecting-related injury and disease among clients of a supervised injecting facility. *Drug Alcohol Depend* 2009;101(2009):132–136.
3. Pieper B, Templin T. Chronic venous insufficiency in persons with a history of injection drug use. *Res Nurs Health* 2001;24:423–432. [PubMed: 11746071]
4. Manckoundia P, Thomas F, Buatois S, Guize L, Jegu B, Aquino JP, Benetos A. Impact of clinical, psychological, and social factors on decreased Tinetti test score in community-living elderly subjects:

- A prospective study with two-year follow-up. *Med Sci Monit* 2008;14(6):CR316–22. [PubMed: 18509275]
5. Lin MR, Hwang HF, Hu MH, Wu HDI, Wang YW, Huang FC. Psychometric comparisons of the timed up and go, one-leg stand, functional reach, and Tinetti balance measures in community-dwelling older people. *J Am Geriatr Soc* 2004;52:1343–1348. [PubMed: 15271124]
 6. Sousa N, Sampaio J. Effects of progressive strength training on the performance of the functional reach test and the timed get-up-and-go test in an elderly population from rural north of Portugal. *Am J Hum Biol* 2005;17:746–751. [PubMed: 16254902]
 7. Tinetti ME, McAvay GJ, Fried TR, Allore HG, Salmon JC, Foody JM, Bianco L, Ginter S, Fraenkel L. Health outcome priorities among competing cardiovascular, fall injury, and medication-related symptom outcomes. *J Am Geriatr Soc* 2008;56(8):1409–16. [PubMed: 18662210]
 8. Allet L, Armand S, Golay A, Monnin D, de Bie RA, de Bruin ED. Gait characteristics of diabetic patients: a systematic review. *Diabetes Metab Res Rev* 2008;24(3):173–91. [PubMed: 18232063]
 9. Soyuer F, Ozturk A. The effect of spasticity, sense and walking aids in falls of people after chronic stroke. *Disabil Rehabil* 2007;29(9):679–87. [PubMed: 17453990]
 10. Finnie A, Nicolson P. Injecting drug use: implications for skin and wound management. *Br J Nurs* 2002;11(6):S17–S28. [PubMed: 11979188]
 11. Schoener EP, Hopper JA, Pierre JD. Injection drug use in North America. *Infect Dis Clin N Am* 2002;16(2002):535–51.
 12. Bergan JJ, Schmid-Schonbein GW, Coleridge Smith PD, Nicolaides AN, Boisseau MR, Eklof B. Chronic venous disease. *N Engl J Med* 2006;355:488–498. [PubMed: 16885552]
 13. Andreozzi GM, Cordova RM, Scomparin A, Martini R, D'Eri A, Andreozzi F, Quality of Life Working Group on Vascular Medicine of SIAPAV. Quality of life in chronic venous insufficiency. An Italian pilot study of the Triveneto Region. *Int Angiol* 2005;24(3):272–7. [PubMed: 16158038]
 14. Palfreyman SJ, Tod AM, King B, Tomlinson D, Brazier JE, Michaels JA. Impact of intravenous drug use on quality of life for patients with venous ulcers. *J Adv Nurs* 2007;58(5):458–67. [PubMed: 17484747]
 15. Phillips T, Stanton B, Provan A, Lew R. A study of the impact of leg ulcers on quality of life: financial, social, and psychologic implications. *J Am Acad Dermatol* 1994;31:49–53. [PubMed: 8021371]
 16. Pieper B, Templin T. Lower extremity changes, pain, and function in injection drug users. *J Subst Abuse Treat* 2003;25:91–97. [PubMed: 14629991]
 17. Pieper B, Kirsner RS, Templin TN, Birk TJ. Injection drug use – an understudied cause of venous disease. *Arch Dermatol* 2007;143:1305–1309. [PubMed: 17938345]
 18. Pieper B, Templin TN, Birk TJ, Kirsner RS. Effects of injection-drug injury on ankle mobility and chronic venous disorders. *J Nurs Scholar* 2007;39:312–318.
 19. Pieper B, Templin TN, Birk TJ, Kirsner RS. Chronic venous disorders and injection drug use: impact on balance, gait and walk speed. *J Wound Ostomy Continence Nurs* 2008;35(3):301–10. [PubMed: 18496087]
 20. Daut RL, Cleeland CS, Flanery RC. Development of the Wisconsin Brief Pain Questionnaire to assess pain in cancer and other diseases. *Pain* 1983;17:197–210. [PubMed: 6646795]
 21. Serlin RC, Mendoza TR, Nakamura Y, Edwards KR, Cleeland CS. When is cancer pain mild, moderate, or severe? Grading pain severity by its interference with function. *Pain* 1995;61:277–284. [PubMed: 7659438]
 22. Tan G, Jensen MP, Thornby JJ, Shanti BF. Validation of the brief pain inventory for chronic nonmalignant pain. *J Pain* 2004;5:133–137. [PubMed: 15042521]
 23. Pieper B, Templin TN, Birk TJ, Kirsner RS. Reliability and validity of a technique to assess lifetime illicit injection drug use. *Ostomy Wound Manage* 2008;54(2):16–34. [PubMed: 18382041]
 24. Tinetti Assessment Tool. [July 18, 2007]. <http://www.sgim.org/TinettiTool.PDF>.
 25. Kopke S, Meyer G. The Tinetti test: Babylon in geriatric assessment. *Z Gerontol Geriat* 2006;39:288–291.
 26. Eklof B, Rutherford RB, Bergan JJ, Carpentier PH, Gloviczki P, Kistner RL, et al. Revision of the CEAP classification for chronic venous disorders: consensus statement. *J Vasc Surg* 2004;40:1248–1252. [PubMed: 15622385]

27. Bollen, KA. Structural Equations with Latent Variables. Wiley; New York: 1989.
28. Templin, TN.; Peters, R.; Aroian, K.; Weglicki, L.; Lewandowski, L. The flexibility and precision of modern psychometric methods for the development and evaluation of research measures.. Symposium presentation at the National State of the Science Congress in Nursing Research; Washington, D.C.. October 12 -14, 2006;
29. Templin T, Pieper B. Causal modeling in WOC. *J Wound Ostomy Continence Nurs* 2003;30(4):168–173. [PubMed: 12851591]
30. James, LR.; Mulaik, SA.; Brett, JM. Causal Analysis: Assumptions, Models, and Data. Sage Publications; Thousand Oaks, California: 1982.
31. Orsted HL, Radke L, Gorst R. The impact of musculoskeletal changes on the dynamics of the calf muscle pump. *Ostomy Wound Manage* 2001;47(10):18–24. [PubMed: 11890075]
32. White JV, Ryjewski C. Chronic venous insufficiency. *Perspect Vasc Surg Endovasc Ther* 2005;17:319–327. [PubMed: 16389426]
33. Eberhardt RT, Raffetto JD. Chronic venous insufficiency. *Circulation* 2005;111:2398–2409. [PubMed: 15883226]
34. Yang D, Vandongen YK, Stacey MC. Changes in calf muscle function in chronic venous disease. *Cardiovasc Surg* 1999;7(4):451–456. [PubMed: 10430530]
35. Kan YM, Delis KT. Hemodynamic effects of supervised calf muscle exercise in patients with venous leg ulceration. *Arch Surg* 2001;136:1364–1369. [PubMed: 11735861]
36. Persoon A, Heinen MM, van der Vleuten CJM, de Rooij MJ, van de Kerkhof PCM, van Achterberg T. Leg ulcers: a review of their impact on daily life. *J Clin Nurs* 2004;13:341–354. [PubMed: 15009337]
37. Heinen MM, Evers AW, Van Uden CJ, Van der Vleuten CJ, van de Kerkhof PC, Van Achterberg T. Sedentary patients with venous or mixed leg ulcers: determinants of physical activity. *J Adv Nurs* 2007;60(1):50–57. [PubMed: 17824939]
38. Panella L, Tinelli C, Buizza A, Lombardi R, Gandolfi R. Towards objective evaluation of balance in the elderly: validity and reliability of a measurement instrument applied to the Tinetti test. *Int J Rehabil Res* 2008;31(1):65–72. [PubMed: 18277206]
39. Tinetti ME, Gordon C, Sogolow E, Lapin P, Bradley EH. Fall-risk evaluation and management: challenges in adopting geriatric care practices. *Gerontol* 2006;46(6):717–25.
40. de Bruin ED, Murer K. Effect of additional functional exercises on balance in elderly people. *Clin Rehabil* 2007;21(2):112–21. [PubMed: 17264105]
41. Lin MR, Wolf SL, Hwang HF, Gong SY, Chen CY. A randomized, controlled trial of fall prevention programs and quality of life in older fallers. *J Am Geriatr Soc* 2007;55(4):499–506. [PubMed: 17397426]
42. Santana-Sosa E, Barriopedro MI, Lopex-Mojares LM, Perez M, Lucia A. Exercise training is beneficial for Alzheimer's patients. *Int J Sports Med* 2008;29(10):845–50. [PubMed: 18401810]
43. Hess JA, Woollacott M, Shivitz N. Ankle force and rate of force production increase following high intensity strength training in frail older adults. *Aging Clin Exp Res* 2006;18(2):107–15. [PubMed: 16702779]
44. Weerdesteyn V, de Niet M, van Duijnhoven HJ, Geuts AC. Falls in individuals with stroke. *J Rehabil Res Dev* 2008;45(8):1195–231. [PubMed: 19235120]
45. Wall JC, Bell C, Campbell S, Davis J. The timed get-up-and-go test revisited: Measurement of the component tasks. *J Rehabil Res Dev* 2000;37:109–113. [PubMed: 10847578]
46. Kelly VE, Schrager MA, Price R, Ferrucci L, Shumway-Cook A. Age-associated effects of a concurrent cognitive task on gait speed and stability during narrow-based walking. *J Gerontol A Biol Sci Med Sci* 2008;63(112):1329–34. [PubMed: 19126845]
47. Attena F. Causal models in conventional and non-conventional medicine. *Med Hypotheses* 1999;53(3):177–183. [PubMed: 10580519]
48. Skrondal A, Rabe-Hesketh S. Latent variable modeling. *Stat Methods Med Res* 2008;17(1):3–4. [PubMed: 18344370]
49. Robins JM. Causal models for estimating the effects of weight gain on mortality. *Int J Obes* 2008;32(S3):S15–S41.

50. Scarlett LB, Julia YL, Thomas RTH. An introduction to causal modeling in clinical trials. *Clin Trials* 2007;4(1):58–73. [PubMed: 17327246]
51. Shkuratova N, Morris ME, Huxham F. Effects of age on balance control during walking. *Arch Phys Med Rehabil* 2004;85(4):582–8. [PubMed: 15083433]
52. van Iersel MB, Kessels RP, Bloem BR, Verbeek AL, Olde Rikkert MG. Executive functions associated with gait and balance in community-living elderly people. *J Gerontol A Biol Sci Med Sci* 2008;63(12):1344–9. [PubMed: 19126847]
53. Cromwell RL, Newton RA. Relationship between balance and gait stability in healthy older adults. *J Aging Phys Act* 2004;12(1):90–100. [PubMed: 15211023]
54. Woollacott M, Shumway-Cook A. Attention and the control of posture and gait: a review of an emerging area of research. *Gait Posture* 2002;16(1):1–14. [PubMed: 12127181]
55. Robson MC, Cooper DM, Aslam R, Gould LJ, Harding KG, Margolis DJ, et al. Guidelines for the prevention of venous ulcers. *Wound Rep Reg* 2008;16:147–150.
56. Vowden KR, Vowden P. Preventing venous ulcer recurrence: a review. *Int Wound J* 2006;3:11–21. [PubMed: 16650207]
57. Newland MR, Patel AR, Prieto L, Boulton AJM, Pacheco M, Kirsner RS. Neuropathy and gait disturbances in patients with venous disease: a pilot study. *Arch Dermatol* 2009;145(4):485–486. [PubMed: 19380677]
58. Callisaya ML, Blizzard L, Schmidt MD, McGinley JL, Lord SR, Srikanth VK. A population-based study of sensorimotor factors affecting gait in older people. *Age Aging* 2009;38(3):290–5.

Figure 1.

Structural equation model of injection-related venous disease with standardized path coefficients. The primary structural paths are shown with thick arrows. The double-headed arrows are correlations among exogenous variables. All coefficients are significant ($p < .05$) except those shown in small italics (four in all).

Table 1

Summary of Variables (N = 713)

Variables		
	<i>M or %</i>	<i>SD</i>
Age, M	46.26	9.06
Gender %Male	46.9	
Ethnicity, % Black	61.7	
Married %	27.4	
HS. Graduate %	64.5	
Working %	30.0	
BMI, M	28.05	6.81
No. Comorbidities, M	2.91	2.15
Years injecting drugs (n = 518), M	13.08	9.77
Years injecting in arms (n = 504), M	9.08	8.15
Years injecting in lower extremities (n = 340), M	9.19	8.40
Moderate-Severe Clinical CEAP %	36.3	
Tinetti Balance Score, M	13.85	2.40
Tinetti Gait Score, M	10.93	1.73
Walk time (meters/second), M	39.20	10.61
Leg pain, M	3.69	3.15