Original Article

Nurses' foot health: perception, behavior, and analysis of the cardiovascular effects of different types of hosiery

Tzu-Hua Weng[1], Tzu-Fan Weng[2], Yu-Hsien Lin[3]

[1]Emergency Department, MacKay Memorial Hospital, Taipei, Taiwan; [2]Poznan University of Medical Science, Poznań, Poland; [3]Department of Plastic Reconstruction Surgery, Shin-Kong Memorial Hospital, Taipei, Taiwan

Contributions: (I) Conception and design: TH Weng; (II) Administrative support: All authors; (III) Provision of study materials or patients: TH Weng; (IV) Collection and assembly of data: TH Weng; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Yu-Hsien Lin, MD. Department of Plastic Reconstruction Surgery, Shin-Kong Memorial Hospital, 6F., No. 30, Sec. 1, Minsheng E. Rd., Zhongshan Dist., Taipei 104011, Taiwan. Email: johnhome35@gmail.com.

Background: Prolonged hours of standing are a central part of a nurse's job and can potentially affect their foot health. Nurses often address these problems by choosing functional stockings (FS) and/or compression stockings (CS). However, it remains to be established whether nurses' perceptions regarding their foot health are related to the choice of hosiery products, furthermore, the decision between FS or CS may impact the arterial health of nurses. The aim of this study was to investigate nurses' awareness of foot health and determine whether FS or CS genuinely benefited the arterial health of the nurses' feet.

Methods: A descriptive cross-sectional study was conducted among nurses worked regular nursing shifts in a tertiary medical center in Taipei, Taiwan after obtaining ethical approval from the Institutional Review Committee. Convenience sampling method was used. Point estimate was calculated at a 95% confidence interval.

Results: Nurses wearing FS exhibited lower brachial mean arterial pressure (MAP) (92.3±11.1 mmHg; P=0.03), end-systolic blood pressure (SBP) (103.4±13.1 mmHg; P=0.02), and pressure-time index (PTI) during systole (2,338.0±378.1 mmHg/s per min; P=0.04) compared with those wearing CS. Nurses wearing CS exhibited lower end-SBP (103.5±14.6 mmHg; P=0.03), prolongation in left ventricular ejection time (LVET) (316.4±19.3 ms; P=0.01), and a reduction in PTI during diastole (3,194.0±414.3 mmHg/s per min; P=0.03).

Conclusions: Nurses without varicose vein issues, seeking to avoid the negative effects of CS, may find that alternative forms of comfortable FS can also contribute to arterial and cardiovascular health.

Keywords: Arterial pressure; stockings; compression; varicose veins; nurses

Received: 20 January 2024; Accepted: 12 March 2024; Published online: 07 May 2024.
doi: 10.21037/ht-24-1
View this article at: https://dx.doi.org/10.21037/ht-24-1

Introduction

Prolonged hours of standing are a central part of a nurse's job. According to previous research, 80–90% of working hours are devoted to standing or walking (1). However, prolonged standing can potentially affect the local circulation in the feet, leading to various issues, including leg swelling and pain, and even lower back pain. In such cases, it can affect nurses' ability to provide appropriate bedside care (1). Recently, increasing attention has been devoted to nurses' health. Nurses often address these problems by choosing more comfortable hosiery, such as functional stockings (FS) and/or compression stockings (CS) (1).

CS were previously considered to be effective in improving venous return, thereby alleviating the problems caused by varicose veins (2). Most nurses believed that

wearing CS was beneficial to their health. However, recent research suggests that wearing CS may lead to user discomfort, such as excessive tightness, material allergies (3), and changes in skin moisture (4). Although CS benefits varicose veins, its efficacy in promoting arterial health in the feet of younger nurses remains controversial.

Cardiovascular issues have been identified among individuals who are required to stand for prolonged periods. Lower limb blood flow and shear rate are significantly reduced during standing, which may worsen the progression of atherosclerosis (5). With advances and developments in biotechnology in recent years, FS have been introduced, with claims of improving foot health, such as having the potential to influence balance (6), and patients with diseases that affect foot health are known to benefit from prescribed stock footwear in terms of clinical outcomes (7).

However, it remains to be established whether nurses' perceptions regarding the choice of hosiery products are accurate and whether FS or CS contribute to arterial health in the feet. The primary focus of this qualitative study was to investigate nurses' awareness of foot health. Additionally, we performed a quantitative analysis to determine whether FS or CS genuinely benefited the arterial health of the nurses' feet. We present this article in accordance with the TREND reporting checklist (available at https://ht.amegroups.com/article/view/10.21037/ht-24-1/rc).

Methods

Subjects

The present study was approved by the institutional review board of a tertiary medical center in Taipei, Taiwan, with requirements for written informed consent waived. Fifty female nurses participated in this study; however, during the study process, six withdrew, resulting in 44 who provided data for analysis. All participants worked regular nursing shifts in clinical practice, which involved prolonged periods of standing. Individuals with chronic inflammatory diseases, severe cardiovascular disease, or other significant systemic diseases, including cardiovascular disease, heart disease, peripheral vascular disease, and respiratory disorders, and those with severe varicose veins [Clinical-Etiology-Anatomy-Pathophysiology (i.e., "CEAP", grade IV–VI), foot injuries, or ulcers] were excluded. Participants with a documented medical history of diabetes mellitus or other chronic metabolic diseases were also excluded.

Hosiery types and measurement device

The FS used in this study (NEORON®, NEFFUL International Holdings Pte., Ltd., Singapore, Singapore) were made from polyvinyl chloride (NEFFUL NEORON®), cotton, nylon, polyurethane and polyester, and made in Japan, while the CS were over-the-calf elastic stockings (Hartmann GmbH, Wolfstein, Germany). Pulsed-wave analysis (PWA) of the central artery and noninvasive blood pressure management was performed using the SphygmoCor XCEL System (ATCOR Medical, Sydney, Australia).

Method and procedures

Face-to-face interviews, 45–105 min in duration, were conducted with the enrolled participants, following semi-structured guidance with open-ended questions designed to elicit responses regarding nurses' perceptions and behaviors regarding their foot health. A range of prompts were also used, including requests for examples or further explanations, and the subjects were encouraged to share their experiences and thoughts. At this stage, the researcher quantified the qualitative data by organizing, reading, coding, and labeling the data.

In addition to the interviews, a comparative study was performed to evaluate the arterial health of those wearing FS and CS. Because cardiovascular tests were one of the main aspects of this study, all subjects were required to abstain from alcohol for >24 h, with no strenuous exercise within 1 h of testing to maintain their heart rate and blood pressure within the normal physiological range before the trial. Baseline measurements, including body temperature, blood pressure, heart rate, and arterial waveform analyses, were performed using the SphygmoCor XCEL device. In a tranquil environment, the quality of arterial waveforms was confirmed in subjects with an operational index exceeding 90%. Subsequently, a rest period was instituted, after which the subjects donned test stocking 1 (either FS or CS) for 20–30 min before undergoing arterial waveform measurements associated with the intervention. Following another rest period, subjects switched to test stocking 2 [either FS or CS (i.e., other than test stocking 1)] and replicated the aforementioned procedure. These steps collectively constituted the PWA procedure used in this study.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013), and was

Table 1 Interviews and questionaries

Statement	Percentage (%)
Ways chosen for promoting foot health	
Wearing CS	73
Foot massage/elevating legs	34
Appropriate work shoes	27
Perception of the benefits of wearing compression stockings	
Reducing foot swelling	40
Relieving leg soreness	25
Preventing varicose vein	10
Maintaining slimmer legs	5
Frequency of wearing compression stockings at work	
Wearing compression stockings (mostly 3–4 days per week)	66
Wearing normal stockings	33
Reasons for unwilling wear compression stockings	
Feeling too tight or uncomfortable	30
Skin sensitivity or itching	15
Difficulty wearing, taking longer to don and remove	15
Improvement recommendations for compression stockings	
Avoiding tightness, improving comfort	16
Increasing breathability	10
Enhancing softness	8
Simplifying the wear processes	8

CS, compression stocking.

approved by the Institutional Review Board of Shin Kong Wu Ho-Su Memorial Hospital (IRB No. 20230511R) on July 13th, 2023. Data in this study are being analysed in aggregate only, study data sets do not include identifiable personal data, and there will be no medical chart review of the subjects. Informed consent was taken from all individual participants.

Data acquisition

Physiological variables measured during PWA included brachial systolic blood pressure [SBP (mmHg)], brachial diastolic blood pressure [DBP (mmHg)], brachial mean arterial pressure [MAP (mmHg)], brachial pulse pressure [PP (mmHg)], central SBP (mmHg), central DBP (mmHg), central PP (mmHg), central MAP (mmHg), end SBP (mmHg), ejection period (ms), left ventricular ejection time [LVET (ms)], pressure-time index (PTI) during systole (mmHg/s per min), PTI diastole (mmHg/s per min), and reflection magnitude (%).

Statistical methods

The interviews and questionnaires were qualitatively analyzed. Data are expressed as mean ± standard deviation (SD) for continuous variables and frequency (percentage) for categorical variables. Comparisons were performed using two-sided tests, and differences with $P<0.05$ were considered to be statistically significant. Bonferroni's multiple comparison test was used to control for the potential statistical biases associated with multiple comparisons, particularly in the context of small sample sizes. Statistical analyses were performed using Prism, version 9 (GraphPad Inc., San Diego, CA, USA).

Results

The 50 female nurses who participated in the survey worked in the intensive care unit (32%), emergency department (56%), or operating room (12%). Cohort characteristics included a mean (± SD) age of 42.4±7 years, height 159.9±4.8 cm, weight 57.2±9.7 kg, and body mass index of 22.3±3.3 kg/m^2.

Nurses working 8 h per shift typically experience various types of foot, musculoskeletal knee, and/or back pain. Findings of the present study revealed that nurses had varying perspectives on how to prevent foot issues or promote foot health, including wearing CS (73%), foot massages/elevating the legs (34%), and wearing appropriate work shoes (27%). Nurses believed that wearing CS could reduce foot swelling (40%), relieve leg soreness (25%), prevent varicose veins (10%), and maintain slimmer legs (5%). Sixty-six percent of all participants wore CS for 3–4 days per week, while 33% wore normal stockings. Some were unwilling to wear CS because they believed that they were too tight or uncomfortable (30%), experienced skin sensitivity or itching (15%), and took longer to don and remove (15%) than others. During the interviews, the nurses also suggested improvements in the CS, including avoiding tightness to improve comfort (16%), increasing breathability (10%), enhancing softness (8%), and simplifying the wearing process (8%) (*Table 1*).

Table 2 Basic demographics and hemodynamics after interventions

Variable	Baseline (n=44) (mean ± SD)	Functional stockings (n=44)		Compression stockings (n=44)	
		Mean ± SD	Adjusted P value*	Mean ± SD	Adjusted P value*
Age (years)	42.4±7.0	–	–	–	–
Height (cm)	159.9±4.8	–	–	–	–
Weight (kg)	57.2±9.7	–	–	–	–
BMI (kg/m^2)	22.3±3.3	–	–	–	–
Heart rate (bpm)	74.1±10.3	74.1±11.0	>0.99	72.7±10.1	>0.99
Brachial SBP (mmHg)	123.7±16.2	120.5±14.9	0.03	121.2±16.9	0.41
Brachial DBP (mmHg)	79.7±10.2	77.6±9.7	0.22	78.3±10.5	>0.99
Brachial PP (mmHg)	44.1±9.3	43.0±8.8	>0.99	42.9±9.8	>0.99
Pulse wave analysis					
Central SBP (mmHg)	113.8±15.0	111.1±14.0	0.051	111.9±15.8	0.74
Central DBP (mmHg)	80.3±10.4	78.3±9.8	0.22	78.8±10.7	>0.99
Central PP (mmHg)	33.5±8.0	32.8±8.1	>0.99	33.1±8.6	>0.99
Central MBP (mmHg)	94.6±11.9	92.3±11.1	0.03	92.8±12.5	0.44
End-SBP (mmHg)	105.7±13.6	103.4±13.1	0.02	103.5±14.6	0.03
Period (ms)	819.2±111.4	822.2±121.1	>0.99	834.2±108.1	0.39
LVET (ms)	310.3±21.7	309.4±23.1	>0.99	316.4±19.3	0.01
PTI systole (mmHg/s per min)	2,406.0±388.2	2,338.0±378.1	0.04	2,376.0±434.9	0.97
PTI diastole (mmHg/s per min)	3,267.0±418.8	3,202.0±409.3	0.10	3,194.0±414.3	0.03
Reflection magnitude (%)	58.3±9.7	58.5±8.3	>0.99	58.3±8.9	>0.99

Analyzed using one-way ANOVA Bonferroni's multiple comparisons test. *, adjusted P value, comparing with baseline. SD, standard deviation; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; PP, pulse pressure; MBP, mean blood pressure; LVET, left ventricular ejection time; PTI, pressure time index; ANOVA, analysis of variance.

PWA measurement

Forty-four participants exhibited no significant differences in heart rate, brachial DBP, or brachial PP between the FS and CS groups. Baseline brachial SBP for control (before wearing any stockings), FS, and CS were 123.7±16.2, 120.5±14.9 and 121.2±16.9 mmHg, respectively. There was a significant decrease in brachial SBP (120.5±14.9 mmHg, P=0.03) compared with baseline and FS (*Table 2*).

There were no obvious differences in central SBP, central DBP, or central PP in subjects wearing the FS and CS compared with baseline. Subjects wearing FS exhibited a trend toward lower central SBP (111.1±14.0 mmHg; P=0.051), although the difference was not statistically significant. Interestingly, findings indicated that subjects wearing FS exhibited lower central MAP (92.3±11.1 mmHg; P=0.03), end-SBP (103.4±13.1 mmHg; P=0.02), and PTI during systole (2,338.0±378.1 mmHg/s per min; P=0.04) compared with those wearing CS. Conversely, subjects wearing CS exhibited lower end-SBP (103.5±14.6 mmHg; P=0.03), prolongation in LVET (316.4±19.3 ms; P=0.01), and a reduction in PTI during diastole (3,194.0±414.3 mmHg/s per min; P=0.03).

Discussion

In this study, a deeper understanding of nurses' perceptions, behaviors, and actual data measurements regarding foot health was obtained through qualitative analysis of questionnaire responses and quantitative analysis of PWA data. This study yielded several noteworthy findings.

Based on the findings of this qualitative survey/interview-

based study, nurses tended to choose wearing CS as a way to enhance foot health, and the majority tended to wear CS for approximately 3 to 4 days per week. Nurses believed that wearing CS was more effective in alleviating foot swelling (40%) and relieving leg soreness (25%) than preventing varicose veins (10%). However, when using CS, nurses frequently expressed concerns, including tightness (30%), skin sensitivity or itching (15%), and difficulty putting them on and removing them (15%). According to a previous report, individuals using CS may experience adverse skin effects such as contact dermatitis (8). In summary, nursing personnel have overlooked the medical utility of CS for the treatment of venous insufficiency (9) while simultaneously enduring discomfort by wearing them with the expectation of achieving non-medical claims, such as reduced swelling.

With regard to cardiovascular health, CS appear to provide advantages for arterial well-being. According to the results of this study, CS increased LVET and decreased end-SBP, suggesting that it may increase cardiac contraction time, leading to benefits in reducing heart rate, SBP, and central SBP. Physiologically, these outcomes may be related to the fact that CS increases the afterload on the heart, thereby prolonging LVET (10). In contrast, end-SBP is currently used as a scientific indicator to predict cardiac afterload. Theoretically, higher end-SBP values correspond to a higher cardiac afterload (11). However, in this study, subjects wearing CS exhibited longer LVET but lower end-SBP values. Nevertheless, more rigorous studies are required to characterize the causal relationship between increased LVET and decreased end-SBP.

Similar to CS, FS have cardiovascular benefits. Participants using FS exhibited reduced brachial SBP, MAP, end-SBP, and PTI systolic curve area. The underlying reasons for these observations are unclear; however, based on previous studies, they may be related to endothelial cells and their associated cytokines. Arterial endothelial cells can influence blood pressure through increased nitric oxide synthase, cyclooxygenase, or soluble guanylyl cyclase activity, thus decreasing oxidative stress or altering endothelial cell membrane potential (12-15). Based on our results, we believe that wearing FS can influence the functioning of vascular endothelial cells, although the exact mechanism by which FS may help lower blood pressure requires more rigorous investigation.

Furthermore, this study revealed two other interesting phenomena: subjects using CS exhibited a decrease in PTI diastole value; and those using FS exhibited a decrease in PTI systole value. PTI diastolic values are a well-known predictor of "coronary artery perfusion" (16) and the use of CS appeared to have a negative impact on coronary artery perfusion. On the other hand, PTI systolic values are medically associated with "cardiac oxygen consumption" (17) and the use of FS appeared to be capable of decreasing cardiac oxygen consumption. We speculate that participants wearing CS may experience increased afterload, consequently extending LVET and reducing the PTI diastolic time. For participants wearing FS, it is possible that FS may reduce SBP, thus lowering afterload on the heart and, consequently, PTI diastolic time, a predictor of cardiac oxygen consumption. Furthermore, the decrease in end-SBP in this study indicated a reduction in the end-SBP-volume relationship, which may be interpreted as a decrease in the strength of cardiac contraction, affording protection to the heart (18). However, this result requires further scientific evidence, and we welcome further discussion(s) regarding specific research proposals.

Nurses often experience numerous foot problems affecting their ability to work. Maintaining good foot health requires regular attention from nurses themselves as well as at the organizational level. Nurses should be educated on how to provide care for their feet. FS, CS, other hosieries, and footwear are convenient, inexpensive, and easily accessible devices that can alleviate foot discomfort and have positive health benefits during work that involves prolonged periods of standing. CS is an appropriate choice for individuals with varicose veins. However, in young women who do not have varicose vein problems and want to avoid the adverse effects of CS, other types of FS may promote arterial and cardiovascular health. Future research should include interventions that target nurses to promote foot health.

Conclusions

Maintaining good foot health requires regular attention from nurses themselves as well as at the organizational level. FS, CS are convenient, inexpensive, and easily accessible devices that can have positive health benefits during work that involves prolonged periods of standing. Nurses without varicose vein issues, seeking to avoid the negative effects of CS, may find that alternative forms of comfortable FS can also contribute to arterial and cardiovascular health.

Acknowledgments

Funding: None.

Footnote

Reporting Checklist: The authors have completed the TREND reporting checklist. Available at https://ht.amegroups.com/article/view/10.21037/ht-24-1/rc

Data Sharing Statement: Available at https://ht.amegroups.com/article/view/10.21037/ht-24-1/dss

Peer Review File: Available at https://ht.amegroups.com/article/view/10.21037/ht-24-1/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://ht.amegroups.com/article/view/10.21037/ht-24-1/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013), and was approved by the Institutional Review Board of Shin Kong Wu Ho-Su Memorial Hospital (IRB No. 20230511R) on July 13th, 2023. Data in this study are being analysed in aggregate only, study data sets do not include identifiable personal data, and there will be no medical chart review of the subjects. Informed consent was taken from all individual participants.

References

1. Mbue ND, Wang W. Nurses' experience with chronic foot pain and their job-the national science foundation foot health survey. Heliyon 2023;9:e14485.
2. Lee Y, Kim K, Kang S, et al. Compression Stocking Length Effects on Oedema, Pain, and Satisfaction in Nursing Students: A Pilot Randomized Trial. Healthcare (Basel) 2020;8:149.
3. Zhang H, Chen YH, Xie Z. Contact allergy due to platinum siloxane complex in elastic compression stockings for varicose veins. Contact Dermatitis 2020;83:427-9.
4. Westphal T, Konschake W, Haase H, et al. Medical compression stockings on the skin moisture in patients with chronic venous disease. Vasa 2019;48:502-8.
5. Caldwell AR, Gallagher KM, Harris BT, et al. Prolonged standing increases lower limb arterial stiffness. Eur J Appl Physiol 2018;118:2249-58.
6. Menz HB, Auhl M, Munteanu SE. Preliminary evaluation of prototype footwear and insoles to optimise balance and gait in older people. BMC Geriatr 2017;17:212.
7. Williams AE, Nester CJ. Patient perceptions of stock footwear design features. Prosthet Orthot Int 2006;30:61-71.
8. Mizuno J, In-Nami H. Allergic contact dermatitis to synthetic rubber, neoprene in compression stockings. Masui 2011;60:104-6.
9. Raetz J, Wilson M, Collins K. Varicose Veins: Diagnosis and Treatment. Am Fam Physician 2019;99:682-8.
10. Burkhoff D, De Tombe PP, Hunter WC. Impact of ejection on magnitude and time course of ventricular pressure-generating capacity. Am J Physiol 1993;265:H899-909.
11. Gibbs CL, Chapman JB. Cardiac mechanics and energetics: chemomechanical transduction in cardiac muscle. Am J Physiol 1985;249:H199-206.
12. Avolio A. Arterial Stiffness. Pulse (Basel) 2013;1:14-28.
13. Craighead DH, Heinbockel TC, Freeberg KA, et al. Time-Efficient Inspiratory Muscle Strength Training Lowers Blood Pressure and Improves Endothelial Function, NO Bioavailability, and Oxidative Stress in Midlife/Older Adults With Above-Normal Blood Pressure. J Am Heart Assoc 2021;10:e020980.
14. Zhou J, Zhu Y, Cheng M, et al. Regulation of vascular contractility and blood pressure by the E2F2 transcription factor. Circulation 2009;120:1213-21.
15. McGuire JJ, Hollenberg MD, Bennett BM, et al. Hyperpolarization of murine small caliber mesenteric arteries by activation of endothelial proteinase-activated receptor 2. Can J Physiol Pharmacol 2004;82:1103-12.
16. Eng C, Lee J, Kirk ES. Improvement of coronary blood flow by augmentation of coronary vascular compliance. J Cardiovasc Pharmacol 1985;7 Suppl 2:S70-4.
17. Oliveros RA, Boucher CA, Haycraft GL, et al. Myocardial

oxygen supply-demand ratio: a validation of peripherally vs centrally determined values. Chest 1979;75:693-6.
18. Zhang Y, Kalhöfer-Köchling M, Bodenschatz E, et al. Physical model of end-diastolic and end-systolic pressure-volume relationships of a heart. Front Physiol 2023;14:1195502.

doi: 10.21037/ht-24-1
Cite this article as: Weng TH, Weng TF, Lin YH. Nurses' foot health: perception, behavior, and analysis of the cardiovascular effects of different types of hosiery. Health Technol 2024;8:2.