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RESEARCH ARTICLE

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Effect of foot care interventions for older adults using day care services

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Abstract

Aim: This study explored the prevalence of foot problems among older adults and the effectiveness of foot care interventions for improving toe-gap force and foot flexibility. Foot problems are very common among people aged 65 years and older. However, the effects of foot care interventions on components underlying these issues (i.e., toe-gap force and foot flexibility) are unclear.

Design: This was a quasi-experimental study.

Methods: Eighteen older adults were divided into three groups: medical foot care intervention, combined intervention and control group. The combined intervention group received medical foot care, foot hygiene and five-toed socks. Toe-gap force and foot flexibility were measured.

Results: The most common foot problems were hallux valgus, toe deformities, nail discoloration and thickness and dryness. Significant differences in right foot toe-gap force were observed between the combined intervention and control groups. There were no significant differences in foot flexibility between groups.

KEYWORDS
foot care, foot problems, older adults, toe-gap force

1 | INTRODUCTION

As people age, the prevalence of foot problems increases. Foot problems include toenail issues/deformities, corns and calluses, bunions, fungal infections, lesser toe deformities, cracks, fissures and macerations. These foot problems may increase foot pain and are more common among women and individuals who are overweight/obese (Benvenuti, Ferrucci, Guralnik, Gangemi, & Baroni, 1995; Dawson et al., 2002; Dunn et al., 2004; Menz, 2016; Menz & Lord, 2001; Menz, Morris, & Lord, 2006). Foot and toe deformities reduce range of motion and decrease strength and plantar tactile sensation (Guidozzi, 2017). Toes are necessary for muscular strength in the lower limbs, postural stability and weight distribution while walking (Hughes, Clark, & Klenerman, 1990). Toe flexor strength as part of toe performance is an independent predictor of balance and function (Menz, Morris, & Lord, 2005; Suwa, Imoto, Kida, Iwase, & Yokochi, 2017). Toe flexor strength is considered a measurable outcome for interventions, such as exercise and medical foot care (Mickle, Caputi, Potter, & Steele, 2016; Yamashita et al., 2019), and is associated with foot structure (Uritani, Fukumoto, Matsumoto, & Shima, 2015). Toe flexor strength is associated with age-related change (2006, & Scott, 22006; Suwa et al., 2017).

Toe flexor strength has been evaluated in various ways. Two kinds of measurements were developed in Japan; toe-grip dynamometer (T.K.K.3364; Takei Scientific instrument Co. Ltd) and toe-gap force measurement (Nissin Industry; Yamashita et al., 2005). Uritani et al. (2015) developed the toe-grip dynamometer, based on the hand grip dynamometer, with assistance from Takei

Scientific Instrument to measure toe-grip strength. Yamashita et al. (2005) developed the toe-gap force measurement. Toe-gap force between the great toe and digitus secundus is exerted through muscles of the lower limbs. Mickle et al. (2016) introduced a method with a developed, reliable protocol, using an emed At-4 pressures platform (Novel GmbH) to measure the effects of progressive resistance training of the foot muscle on toe flexor strength.

Further, while toe exercises are important, toe problems include issues with the skin, nails and deformities. In the current study, medical foot care alone and a combined intervention, which included medical foot care, five-toe socks and foot hygiene, were considered effective for improving toe-gap force and foot flexibility, as they served as preparatory measures for ensuring mobility in the toes and feet. Foot flexibility, reflected in toe-curl ability, was also considered a measurable outcome, as toe-curl ability involves the range of motion in toe flexion (Uritani et al., 2015).

The objectives of the present study were to (a) explore the prevalence of foot problems among older adults and (b) examine the effects of medical foot care and a combined foot care intervention, which included medical foot care, five-toe socks and foot hygiene, on the enhancement of toe-gap force and foot flexibility.

2 | BACKGROUND

Toe performance is considered critical in controlling foot movement and assisting with propulsive force when walking (Misu et al., 2014). Toe flexion is an action produced by activity of the intrinsic and extrinsic plantar muscles (Soysa, Hiller, Refshauge, & Burns, 2012). Toe movement is generated by the collaboration of flexor-tensor muscles that compose the lowest part of the foot (Yamashita et al., 2005). Reduced toe flexion, due to hallux valgus and lessor toe deformities, increases fall risk among older adults (Mickle, Munro, Lord, Menz, & Steele, 2009).

Foot discomfort likely hinders the proper performance of toes. Several epidemiological studies have reported that foot discomfort in old age is an important factor for predicting instrumental and basic activities of daily living, walking speed, quality of life and depression (Awale, Dufour, Katz, Menz, & Hannan, 2016; Guidozzi, 2017; Menz, 2016; Stolt et al., 2010). Foot discomfort can be alleviated through proper care, including nail care, corn removal, skin care, massages, baths and foot and toe exercises.

Aging accelerates foot discomfort in older people. The ability to care for one's feet decreases with age. Moreover, the decline of physical function, including visual impairment, inability to reach one's own feet and diminished manual dexterity, is prevalent (Stolt, 2013b). Foot health, even in healthy older adults, is often neglected (Campbell, 2006). Substantial nail changes are often overlooked and not brought to the attention of primary caregivers (Abdullah & Abbas, 2011).

In addition, age-related changes in the feet include skin alterations, toenail changes and toe deformities (Edelstein, 1988; Lawton, 2018). Dunn et al. (2004) reported that over half of their 784 participants (mean age = 74.5) had corns or calluses and over a third had fungal infections, fissures and/or toe macerations.

Nail disorders, including thickened, elongated and ingrown nails resulting from inadequate foot hygiene, can be extremely painful and disabling (Menz, 2016). Nail changes could affect various components of the nail unit and represent normal age-related nail alterations or abnormalities that require immediate intervention (Abdullah & Abbas, 2011). Lower toe flexor strength due to muscle atrophy with aging is likely to affect the ability to walk (Mickle et al., 2016). Loss of muscle mass, strength and function are some of the most striking age-related changes (Volpi, Nazemi, & Fujita, 2004). With aging, a decrease in lower toe flexor strength due to muscle atrophy is likely to affect the ability to walk (Mickle et al., 2016). In previous literature, researchers observed the effects of interventions involving toe exercise and medical foot care on toe flexor strength or toe-gap force. Mickle et al. (2016) reported that progressive resistance training programmes improved toe flexor strength. Moreover, Yamashita et al. (2019) reported the effects of foot and toenail care on toe-gap and knee-gap force. Further, Nomoto and Kawasumi (2007) observed that medical foot care administered over 1 year improved knee elevation, walking balance and the rotation range of the ankle.

A few studies have examined the benefits of five-toe socks (Shinohara & Gribble, 2010; keisuke, 2011), but their effects could have been overlooked due to a lack of research. The association between the foot hygiene method used in the current study and toe-gap force and foot flexibility has not been examined extensively in previous research. The effects of the combined intervention involving five-toe socks, medical foot care and foot hygiene on toe-gap force and foot flexibility were expected to be synergistic.

3 | METHODS

3.1 | Study design

A quasi-experimental study was conducted. The control group was unable to visit the day care or day rehabilitation centre more than twice because of other commitments. Participants in the intervention groups, who attended the centres more than twice, were randomly allocated to one of two groups. Foot assessment was conducted before the intervention. Toe-gap force and foot flexibility were checked before and after the intervention. The study adhered to the SQUIRE guidelines version 2.0 (http://www.squire-statement.org/).

3.2 | Ethical considerations

The study conformed to the Declaration of Helsinki. The Ethical Committee of Meinankai Medical Corp in Japan approved this study (19 May 2017). All participants were informed that participating in the study or withdrawing their participation midway through the research would not result in any adverse consequences. Except for

a few participants who lived alone and whose cognitive functions were intact, family members were also informed about the study. Written informed consent was obtained from participants and/or their family members.

3.3 | Setting and participants

In total, 18 participants were recruited from two institutions: an adult day care service centre and an adult day care rehabilitation centre in Aichi prefecture. Fifteen participants lived with their families, but most of their family members worked during the day. Three participants lived alone. Sixty people attending adult day care and day service centres were initially contacted by the author, but only 18 provided informed consent and were subsequently included in the study.

In Japan, there are two types of day care centres for older adults. Day care service centres provide single-day support including assistance with hygiene, meals, excretion, functional physical training and recreational activities (i.e. music and games). Day care rehabilitation centres provide individual exercise supported by a physical therapist. Staff members at both types of centres typically provide transportation to and from the centre.

The long-term health insurance system for older adults in Japan is a compulsory public programme run by the municipal government and specified districts in Tokyo. The programme covers care for both home-based and institutionalized patients. Those insured under the long-term insurance system include (a) people aged 65 years or older (Category 1) and (b) people aged 40–64 years who are covered by a health insurance program (Category 2). Applicants for care services must be screened and successful applicants are categorized into one of seven care need levels: two support levels (1 and 2) and care levels 1 through 5. Beneficiaries are categorized based on an assessment made by the municipal government and doctors' written opinions (Health & Welfare Bureau for the Elderly, Ministry of Health, Labour & Welfare, 2016).

The inclusion criteria were an age of 65 years or older, support level 1 or 2 or Care Level 1 or 2 and attendance at the adult day care centre or day service centre at least once per week. The exclusion criteria were an inability to understand the study requirements, the presence of ulcers, considerable redness of foot skin, foot pain and possible mental effects of participation or lower cognitive function. Participants' cognitive function was assessed subjectively according to the expertise of staff members, who observed the manifestation of diminished short-term memory abilities (e.g., easily forgetting things on a daily basis). The possibility of mental effects, such as emotional instability and sleep disturbance, due to participation was based on the daily assessment of care and determined by staff members.

Participants in the control group were selected from those who agreed to participate in the study and attended the day care service or day care rehabilitation centre only once per week. The remaining participants were allocated randomly into two intervention groups. Each group comprised six participants.

The study was conducted from August–November 2017. Three participants dropped out during the study period and new participants were included. The study termination date was extended to January 2018 to accommodate these participants. The researcher visited the sites at midday for 30 min from Monday–Friday during the study period.

3.4 | Measurements

3.4.1 | Basic information

Demographic information was collected from all participants. The information gathered included sex, age, disease history, level of nursing care, fall history and living status.

3.4.2 | Foot assessment

Foot assessment was critical to understand the condition of the foot and identifying foot problems before the interventions. The medical foot care intervention allowed participants' feet to function as normally as possible. If a participant's nails were thick, they were ground down, and if there was a corn on the plantar surface of the foot, it was ground down using a grinder. Participants could not wear five-toe-socks if their toenails were too long or thick, or if they experienced pain due to close contact between the toes. Initially, the presence of foot problems was examined using a foot assessment sheet created for this study. Although there are no national licenses related to foot care in Japan, the author obtained a certificate from a private foot care school, following an additional study related to foot care concerns. The assessment items comprised the skin and nails, toe deformities, circulation and nerve conditions. Skin assessment included skin redness, purpura, stratum corneum, oedema of about 2+, skin dryness, tinea pedis, suspicion of tinea pedis, callus or corns, maceration between toes. Any doubt regarding tinea pedis was judged using a Japanese textbook about tinea pedis as a reference. Oedema was assessed when skin was pressed over tibia and the area pressed was run over with pads of finger (1+ Barely detectable impression when finger is pressed into skin; 2+ Slight indentation, 15 s to rebound; 3+ deeper indentation, 30 s to rebound; 4+ deep indentation, >30 s to rebound).

Toenail assessment included deformity, color, onychomycosis, suspicion of onychomycosis and nail thickening and ingrown nails, while toe deformity included hallux valgus, quintus varus, hammer toes and mallet toes. Toenails with a thickness of 2 mm or more were considered thick. Toenail colour was evaluated using a Japanese textbook about toenails. Foot deformities included hallux valgus, quintus varus and hammer toes. Hallux valgus of <15 degrees and a first-second intermetatarsal angle (IMA) of <9 degrees were considered normal (Mann & Coughlin, 1993).

Nerve conditions included numbness. The researcher touched participants' skin and asked whether or not she/he could feel it (responses: yes or no). Circulation included skin colour, skin coldness, palpable dorsalis pedis and posterior tibial arteries.

Foot condition was assessed using the assessment sheet developed for this study based on a literature review and expertise in nursing and foot care. If patients did not have a given symptom, a score of 0 was recorded. If there was an arch problems in the right or left foot, one point was recorded for the corresponding foot and two points were recorded if both feet were affected. If there was a problem, such as a nail disorder or deformity, on each toe of the right or left foot, one point was recorded.

3.4.3 | Toe-gap force measurement

A device was used to measure toe-gap force before and after the intervention period (Nissin Industry, nissinsangyo.co.jp). A wide range of muscles related to the plantar, such as the flexor hallucis brevis, the flexor digitorum longus, the flexor digitorum brevis, are examined using this instrument to measure toe-gap force (Yamashita et al., 2005). Participants were asked to sit with the trunk in a vertical position, with hip and knee joints at 90 degrees and hold their ankle joints in a neutral position. A bar was tucked between the first and second toes, and toe-gap force was measured in kilograms. If toe-digit speed was slow, toe-gap force was presumed to be limited. The toe-grip dynamometer (T.K.K.3364, Takei Scientific instrument Co. Ltd; Suwa et al., 2017) involves measuring impact on the flexor pollicis brevis, flexor pollicis longus, lumbricals, flexor brevis and flexor longus (Soma et al., 2016). For the current study, the toe-gap force measurement was used because it was previously used to examine the association between foot problems and toe-gap force (Yamashita et al., 2019).

3.4.4 | Foot flexibility

Foot flexibility was used as an index of toe-curl ability. Foot flexibility was correlated with the ankle dorsiflexion angle. Toe-curl ability (percentage) was calculated using the following method: foot length − flexed foot length of a participant in a seated position. Toe-curl ability comprises the range of toe flexion motion, which involves the hallux and arch contraction (Uritani et al., 2015).

3.5 | Intervention

The baseline assessment was conducted through face-to-face interviews by the author. Participants were divided into three groups: medical foot care intervention, combined intervention and control. Medical foot care was provided by the author and involved nail care using a grinder and nail clipper, callus removal with a nail grinder, a foot bath, foot and toe massages and the application of ointment. The author acquired the methods used in the process of obtaining a German foot care method known as fuss fledge. The entire process took approximately 20 min and was conducted twice per month. The soft massage, which focused on toe and ankle flexibility, took 5–10 min to complete and was provided once per week. The control group received regular care by staff at day care services. The combined intervention group received medical foot care twice per month. In addition, foot hygiene was provided by nurse care workers and included washing of the toes, toe grooves, heels and the skin between the toes with a sponge and toe brush; this was administered by nurses or nursing care workers twice per week while assisting participants with showering. After bathing, participants wore five-toed socks, which were fit with the assistance of nurses and nursing care workers twice per week until the end of the service. As older adults were unable to fit the five-toed socks themselves, because of a decline in physical flexibility, fine motor skills and eyesight, the cooperation of the nurses and nursing care workers was necessary.

To help nurses and nursing care workers understand the purpose of the study, the author explained the study content and conducted foot care sessions (lasting approximately 1 hr), targeting the staff a few times before the intervention, using a visual presentation and a display of foot care products. The author explained the foot-washing method with a sponge and toe brush using a mildly acidic soap. In addition, the author provided staff members with a one-page pamphlet that included instructions as to the use of the toe brush.

3.6 | Statistical analyses

Data were analysed using descriptive statistics. Pre- and postintervention difference scores were also calculated and a multivariate linear model (Tukey's HSD) was used. SPSS Statistics 24 (IBM Corp.) was used in all analyses. p Values of <0.05 were considered statistically significant in all tests.

4 | RESULTS

Demographic data are shown in Table 1. The average ages for the medical and combined foot care intervention groups were 80.2 (*SD* 7.5) years and 86.8 (*SD* 3.6) years, respectively. The average age of the control group was 86.7 (*SD* 4.5) years. Four, five, five and four participants received support level 1, support level 2, care level 1 and care level 2, respectively.

4.1 | Foot prevalence

Foot problems are shown in Table 2. The prevalence of foot problems was high in all groups. The most common problems were hallux valgus, toe deformities, nail discoloration, nail thickness and dryness, which affected more than 50% of participants, followed by arch deformities, coldness and maceration between the toes (right foot), which affected more than 33% of participants.

4.2 | Toe-gap force and foot flexibility

Results of the toe-gap force and foot flexibility tests are shown in Table 3. The postintervention change (at 3 months) in toe-gap force and foot flexibility were compared between groups. For toe-gap force in the right foot, there was a 0.65 kg increase in the combined intervention group. In the medical foot care and control groups, the mean changes were −0.02 and −0.35 kg, respectively. Therefore,

TABLE 1 Baseline characteristics of participants

	Medical foot care (*N* = 6)		Medical foot care, five-toe socks and foot hygiene (*N* = 6)		Control (*N* = 6)		
	N	%	*N*	%	*N*	%	*p*-Value
Sex							
Men	0	0	1	17	0	0	1.000
Women	6	100	5	83	6	100	
Age (Average ± *SD*)	80.2 ± 7.5		86.8 ± 3.6		86.7 ± 4.5		0.087
Long-term insurance							
Support level 1	1	17	0	0	3	50	0.430
Support level 2	2	33	1	17	2	33	
Care level 1	1	17	3	50	1	17	
Care level 2	2	33	2	33	0	0	
Medical condition							
Diabetes	1	17	2	33	1	17	0.845
Spinal canal stenosis	0	0	1	17	1	17	
Stroke	0	0	1	17	0	0	
Heart condition	0	0	1	17	0	0	
Lumber problem	1	17	0	0	0	0	
Pancreatitis	1	17	0	0	0	0	
Fracture	1	17	0	0	0	0	
Alzheimer	1	17	0	0	0	0	
Heart problem	0	0	0	0	2	33	
None	1	17	1	17	2	33	

Note: Sex, Long-term insurance, Medical condition: Fisher's exact test, Age: One-way ANOVA.

medical foot care alone did not translate into a change in toe-gap force. However, the difference in toe-gap force between the combined intervention and control groups was significant (p = 0.022, Tukey's HSD). No significant differences in foot flexibility were observed.

Mean toe-gap force in the right foot was 1.23 kg in the medical foot care group before the intervention, while the combined intervention and control groups showed a force of 0.82 and 1.83 kg, respectively. According to the instruction manual for toe-gap force measurement, toe-gap force of ≤3 kg for men and <2.5 kg for women indicates weakness.

5 | DISCUSSION

The present study explored the prevalence of foot problems and the effectiveness of medical foot care alone and the combined intervention in improving toe-gap force and foot flexibility in older adults using day care services. There was some evidence of associations between medical foot care and toe-gap force and foot flexibility. The combined intervention involved the trial of a new combination of methods, in contrast to conventional interventions, such as toe exercises or medical foot care alone, as an effective means of enhancing toe-gap force and foot flexibility. The combined intervention included medical foot care, five-toe socks and foot hygiene. The main reason for introducing the combined intervention was to solve foot problems and adjust foot status to be as normal as possible. A normal foot is considered to be a foot without problems such as nail or skin deformities. It is difficult to adjust the foot completely in older adults; however, systematic foot assessment and considerable care could lead to improved mobility in toes and toe-curl ability.

Various foot problems were observed in participants in systematic assessments. Although several participants experienced skin dryness and toe deformities, calluses and corns (due to pressure or compression) were uncommon. One reason for this could be that the sample did not include individuals who walked frequently. However, the high prevalence of dry skin and arch problems, including hallux valgus, was consistent with previous research (Dunn et al., 2004; Menz & Lord, 2001; Menz, 2016).

With aging, changes in skin condition and foot structure and function occur. Heredity may associate with foot structure to some extent. An unmatched population-based case–control study (Menz et al., 2016) showed a significant association between the use of shoes with a narrow toe box and hallux valgus, in that a critical period of constrictive footwear led to structural changes in the foot

TABLE 2 Prevalence of foot problems (a) Right and (b) Left

	Medical foot care (*N* = 6)		Medical foot care, five-toe socks, and foot and toe hygiene (*N* = 6)		Control (*N* = 6)	
Right foot	***N***	**%**	***N***	**%**	***N***	**%**
(a) Right						
Skin redness, purpura	3	50	3	50	1	17
Stratum corneum	0	0	1	17	0	0
Oedema about 2+	3	50	1	17	0	0
Skin dryness	4	67	3	50	3	50
Tinea pedis	1	17	0	0	0	0
Suspicion of tinea pedis	0	0	1	17	0	0
Callus or corn on skin	1	17	1	17	2	33
Maceration between toes	3	50	4	67	2	33
Nail discoloration	4	67	3	50	5	83
Nail thickness	3	50	4	67	3	50
Onychomycosis	2	33	1	17	1	17
Suspicion of onychomycosis	1	17	2	33	1	17
Other nail disease	0	0	2	33	0	0
Winding claw	2	33	0	0	2	33
Toe deformity	4	67	6	100	3	50
Arch deformity	4	67	2	33	3	50
Hallux valgus	3	50	4	67	4	67
Varus small toe	3	50	0	0	0	0
Sensory impairment	0	0	0	0	3	50
Coldness to the touch	3	50	3	50	2	33
Inability to touch dorsalis pedis artery	0	0	0	0	0	0
Inability to touch posterior tibial artery	0	0	0	0	1	17
(b) Left						
Skin redness, purpura	4	67	4	67	0	0
Stratum corneum	0	0	1	17	0	0
Oedema about 2+	3	50	1	17	0	0
Skin dryness	4	67	3	50	3	50
Tinea pedis	0	0	0	0	0	0
Suspicion of tinea pedis	0	0	0	0	0	0
Callus or corn on skin	1	17	1	17	1	17
Maceration between toes	2	33	2	33	1	17
Nail discoloration	5	83	3	50	3	50
Nail thickness	4	67	5	83	3	50
Onychomycosis	1	17	1	17	0	0
Suspicion of onychomycosis	3	50	1	17	1	17
Other nail disease	0	0	2	33	0	0
Winding claw	2	33	0	0	2	33
Toe deformity	5	83	5	83	4	67
Arch deformity	4	67	3	50	2	33
Hallux valgus	4	67	5	83	4	67
Varus small toe	2	33	1	17	0	0
Sensory impairment	0	0	0	0	2	33
Coldness to the touch	3	50	4	67	2	33
Inability to touch dorsalis pedis artery	0	0	0	0	0	0
Inability to touch posterior tibial artery	0	0	0	0	1	17

TABLE 3 Toe-gap force and foot flexibility

	Medical foot care ① (*N* = 6)		Medical foot care, five-toe socks and foot hygiene ② (*N* = 6)		Control ③ (*N* = 6)		*p*-Value (Tukey's honest significant difference)		
	Average	*SD*	Average	*SD*	Average	*SD*	① versus ②	① versus ③	② versus ③
Toe-gap force (kg)									
Right									
Before	1.23	0.96	0.82	0.55	1.83	0.85			
After	1.22	0.54	1.47	0.62	1.48	0.62			
Difference	−0.02	0.64	0.65	0.41	−0.35	0.63	0.141	0.582	0.022[a]
Left									
Before	1.52	0.93	0.95	0.50	1.88	0.74			
After	1.27	0.84	1.30	0.69	1.88	0.70			
Difference	−0.25	1.03	0.35	0.45	0.04	0.21	0.309	0.765	0.737
Foot flexibility (cm)									
Right									
Before	1.75	1.53	2.02	0.72	2.02	1.00			
After	1.25	1.02	2.13	0.85	1.57	1.07			
Difference	−0.50	0.71	0.12	0.85	−0.45	0.94	0.432	0.994	0.489
Left									
Before	2.07	1.37	1.65	0.71	1.80	1.00			
After	1.58	0.95	1.72	0.51	1.98	0.90			
Difference	−0.48	0.64	0.07	0.81	0.06	0.77	0.424	0.465	1.000

[a]*N* = 5 for the left foot for control due to injury.

and the development of hallux valgus in older age. Hannan et al. (2014) examined the heritability of three disorders (hallux valgus, lesser toe deformities and plantar forefoot soft tissue atrophy) in 2,446 Caucasian men and women. Their results showed that prevalence rates for hallux valgus, lesser toe deformities and plantar soft tissue atrophy were 31%, 29.6% and 28.4%, respectively, and they provided scientific confirmation of heritability.

There is a lack of research worldwide examining maceration between the toes; however, this study showed that 27.8% of all participants experienced this problem. Stolt et al. (2013a, 2013b) developed a foot health assessment instrument and recommended that the skin between the toes should be examined regularly. Moreover, it is necessary to monitor the skin carefully while washing and choose appropriate methods for protecting this fragile tissue.

There are two points (not stated in Table 2) highlighted in the current study that should be addressed further but have not been discussed extensively in previous literature. First, there was an accumulation of dirt between the toenails and nail grooves in 75% of participants. Second, many participants had long toenails. Adams and Johnson (1998) and Edelstein (1988) posited that long toenails were a key characteristic of self-neglect among older adults. Menz (2016) reported that difficulties with cutting toenails are common in this population, as adequate joint flexibility and high levels of manual dexterity and visual acuity are required for this function but may decline with age. As Love (1995) noted, nurses also hesitate to undertake toenail trimming because of fear of causing damage and a lack of confidence in the techniques involved.

The prevalence rates for dirt between the toenails and nail grooves are unknown due to a lack of previous literature. The trimming of long nails, removal of dirt between the toenails and nail grooves and treatment of maceration between the toes are significant considerations for foot health. Therefore, these items should be included in foot assessment sheets.

Although participants might have preferred to care for their own feet, they were unable to do so because of a loss of vision, lack of joint mobility and/or lack of muscle force production. Treating maceration between the toes and removing dirt accumulated between the toenails and nail grooves is difficult, even for those with full functionality. It should be noted that such conditions could arise for reasons other than the neglect of self-care.

Given the prevalence of foot problems in older adults, this study used a medical foot care intervention and a combined intervention that included medical foot care, five-toe socks and foot hygiene. These interventions are considered as a means of preparatory foot care, rather than a foot care exercise, to improve mobility and enhance toe-gap force and foot flexibility.

The present results showed that the combined foot care intervention was effective in improving right foot toe-gap force. A higher

toe-gap force is thought to generate an effective collaboration with flexor-tensor muscles in the lower limbs and to prevent falls (Yamashita et al., 2005). No statistically significant changes in left foot toe-gap force or foot flexibility were observed, although average toe-gap force and foot flexibility improved following the intervention. Moreover, there was no significant improvement in toe-gap force or foot flexibility with medical foot care alone. Possible reasons for the effect of the combined foot care intervention on right foot toe-gap force should be considered. For example, washing the foot, including the toe grooves and heels, in a foot bath and during a shower could improve cleanliness. In addition, stimulating the extremities in a warm environment could promote blood flow and heating the fascia and tendons could enhance viscoelasticity, which improves the elasticity of related muscles and soft tissues (Mutungi & Ranatunga, 1998). Further, as individual muscle fibres are surrounded by capillaries connected to veins and arteries when toe and foot muscles remain in stressful positions or are not exercised, blood flow will likely be reduced. Therefore, enhancing blood flow via foot hygiene leads to improved muscle movement. Dirt that had accumulated between toenails and nail grooves was removed by the author using a soft toe brush, grinder, or a German tool referred to as a nail *sonde* (nagelprodukte.de). Moreover, dirt or dead skin accumulation under the toe nail could cause nail deformities, pain, or capillary pressure and the alleviation of pain or lessor capillary pressure could enhance toe mobility.

Few studies have examined the benefits of five-toe socks. In some studies written in Japanese, these socks have been effective in preventing skin problems caused by humidity and adhesion between the toes and improved blood flow by allowing greater joint range motion. Nevertheless, additional research examining the effective use of five-toe socks is required. Medical foot care itself was not significantly effective in improving toe-gap force or foot flexibility; however, the combined intervention could work in synergy to reduce foot problems. Further research is required to improve the utility of foot care interventions.

The study was subject to some limitations, which should be noted. For example, although 60 people were approached to participate in this study, only 18 provided consent and were ultimately included in the analysis. In addition, there was no device available to assess changes in blood flow. Furthermore, the effects of medical foot care, five-toe socks and foot hygiene were not examined separately. The distinct examination of each intervention factor could provide a more precise picture of intervention efficacy and areas for improvement. Another limitation was that the associations between particular foot conditions (e.g., hallux valgus, the degree of hallux valgus and arch problems) and toe-gap force and foot flexibility were not analysed. Dirt between toenails and nail grooves was not an original assessment feature, but was addressed because of its high prevalence in the study sample. Therefore, additional items, such as dirt between toenails and nail grooves, should be included in foot assessments. Moreover, the quantified difference in each foot condition item between pre- and postintervention assessments could be correlated with differences in toe-gap force and foot flexibility via interventions. In addition, the present methods and interventions could be refined for application in larger populations.

6 | CONCLUSION

The present findings revealed a high prevalence of foot problems among older adults and the combined foot care intervention contributed to improvements in right foot toe-gap force. Therefore, combined interventions could be a useful means of improving toe strength and subsequent lower limb function in this population. Future research should address the unique contribution of foot care features to the improvement of health and well-being outcomes.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHORS' CONTRIBUTIONS

F.K. contributed to the conception, design of this study, and performed the statistical analysis. She drafted and reviewed the manuscript.

ETHICAL APPROVAL

The study conformed to the Declaration of Helsinki. The Ethical Committee of Meinan Association approved this study (Date of approval: 19 May 2017).

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