

A 10-Week Community-Based Barefoot Walking Program: Mobility-Related Functional Outcomes and Selected Health Indicators in Older Adults – A Non-Randomized Controlled Study

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Abstract

Background

This study examined changes in mobility-related functional outcomes, body composition, blood pressure, and blood biochemical markers during a community-based barefoot walking program for older adults.

Methods

In this non-randomized controlled community-based intervention, 30 adults aged 60–79 years were allocated to barefoot walking or usual-lifestyle control groups ($n = 15$ each); 25 completed the study (barefoot walking, $n = 12$; control, $n = 13$). Supervised sessions occurred three times weekly for 10 weeks, progressing from soft sand to combined sand-and-gravel surfaces. Outcomes were evaluated using two-way repeated-measures analysis of covariance controlling for age.

Results

Group $\times$ Time interactions were observed for the 2-min Step Test ($F = 15.878$, $p < 0.001$, partial $\eta^2 = 0.419$), 30-s Chair Stand Test ($F = 6.606$, $p = 0.017$, partial $\eta^2 = 0.231$), Figure-of-8 Walking Test ($F = 6.506$, $p = 0.018$, partial $\eta^2 = 0.228$), body fat mass ($F = 5.813$, $p = 0.025$, partial $\eta^2 = 0.209$), percent body fat ($F = 4.800$, $p = 0.039$, partial $\eta^2 = 0.179$), and waist circumference ($F = 9.830$, $p = 0.005$, partial $\eta^2 = 0.309$). Step-test performance increased from 113.33 ± 8.03 to 126.33 ± 10.68 repetitions in the barefoot group but decreased from 95.85 ± 13.37 to 91.00 ± 13.67 in controls. Blood pressure, fasting plasma glucose, and lipid measures exhibited no significant interactions.

Conclusions

The observed pattern favored functional aerobic endurance and selected anthropometric measures, with no clear cardiometabolic response. Non-randomized allocation and the absence of a conventional shod-walking comparator preclude barefoot-specific causal inference.

Trial registration

Clinical Research Information Service (CRIS), Korea Disease Control and Prevention Agency, National Institute of Health, KCT0012556. Registered 4 September 2026. Retrospectively registered.

Background

As populations age, the focus of later-life health has expanded beyond the presence or absence of disease toward the preservation of functional ability. The World Health Organization defines healthy aging as the development and maintenance of functional ability that enables well-being, with mobility as a central component [1]. Age-related declines in strength, balance, aerobic capacity, and gait performance can restrict community mobility and make everyday activities more difficult. Reviews of

community-based interventions indicate that structured physical activity supports several mobility-related outcomes, although responses differ by program and functional domain [2, 3].

For an exercise program to matter in practice, it must be deliverable within the settings older adults already use. Walking meets that requirement, requiring little specialized equipment and fitting naturally into familiar community environments. In a systematic review of walking-only interventions among community-dwelling older adults, walking endurance and health-related quality of life tended to improve, whereas findings for other physical functions were inconsistent and the certainty of evidence was very low [4]. Therefore, the relevant question is not whether every form of walking produces broad benefits, but which outcomes change under specific and accessible walking conditions.

Barefoot walking presents one such condition because removing footwear changes sensory exposure and gait mechanics. Franklin et al. [5] documented differences between barefoot and conventional footwear conditions in spatiotemporal parameters, lower-limb kinematics, kinetics, and muscle activity. Nevertheless, a difference in gait is not, by itself, evidence of better function. Older women walked more slowly, took shorter steps, and showed greater gait variability when barefoot than when wearing standardized footwear [6]. Another study of balance recovery in older adults reported lower variability in selected barefoot gait measures [7]. These contrasting findings come largely from short-term comparisons, leaving the response to a sustained community-based program unresolved.

The walking surface adds another dimension. Exercise on hard, soft, and sand surfaces improved functional performance in community-dwelling older adults, with some complex motor tasks showing larger changes on soft or sand surfaces [8]. Although these results highlight the potential influence of surface demands, the study did not isolate barefoot exposure. Physical activity participation in older age is also shaped by program availability and access to suitable outdoor environments [9]. Collectively, these considerations support evaluating walking programs where older adults actually live and exercise, rather than assuming that short laboratory comparisons capture their community-level effects.

This study aimed to examine whether a 10-week supervised, community-based barefoot walking program affected mobility-related functional outcomes relevant to active aging, although independence itself was not directly measured.

Methods

Study design, participants, and ethics

This non-randomized, community-based controlled intervention was conducted in a rural area of Andong, Gyeongsangbuk-do, Republic of Korea. Community-dwelling older adults were recruited through convenience sampling in collaboration with local public health institutions. Group allocation was non-random, reflecting participant availability and willingness, recruitment circumstances, and practical constraints related to agricultural schedules and rural life. Functional performance assessments were conducted by trained assessors who were blinded to group allocation.

Individuals were included if they resided in Andong, were aged 60–79 years, were able to understand the study purpose and procedures, were willing to participate, and did not regularly participate in high-intensity exercise. Individuals were excluded if they used insulin or oral glucose-lowering medication for diabetes, were simultaneously participating in another exercise intervention, or had a medical condition considered incompatible with safe barefoot walking. These medical conditions included active foot wounds or ulcers, severe foot deformity, severe lower-limb musculoskeletal pain, recent lower-limb injury or surgery, and neurological or vestibular disorders affecting gait or balance.

The study was approved by the Institutional Review Board of Andong National University (approval number: 1040191-202408-BR-003-01) and was conducted in accordance with the tenets of the Declaration of Helsinki. All participants voluntarily provided written informed consent after receiving an explanation regarding the study purpose, procedures, and potential risks. The study was retrospectively registered with the Clinical Research Information Service (CRIS), Korea Disease Control and Prevention Agency, National Institute of Health (registration number: KCT0012556; date of registration: 4 September 2026).

Table 1
Baseline characteristics of the participants

Characteristic	Barefoot walking (n = 12)	Control (n = 13)	Standardized mean difference
Age (years)	66.50 ± 5.20	71.38 ± 3.25	1.138
Sex, male/female, n	7/5	4/9	0.555
Height (cm)	162.80 ± 8.21	156.16 ± 11.15	0.674
Weight (kg)	61.89 ± 9.91	63.38 ± 12.20	0.133
BMI (kg/m ²)	23.26 ± 2.57	25.85 ± 3.48	0.843
Waist circumference (cm)	81.88 ± 8.61	86.46 ± 10.77	0.468

Values are expressed as mean ± standard deviation unless otherwise indicated. BMI, body mass index.

Study procedures and monitoring

Following participant recruitment, baseline assessments were conducted in August 2024. The barefoot walking group attended supervised sessions three times per week for 10 weeks between August and October 2024. During this same period, control participants received no structured exercise intervention and were instructed to maintain their usual lifestyle. Post-intervention assessments followed the same procedures as the baseline assessments.

Sessions were held in an outdoor riverside community setting under the supervision of a doctoral-level exercise-science professional. Research assistants supported program delivery and assessment, while a nurse from a local public health institution collected blood samples. Trained assessors, familiar with the Korea National Fitness 100 procedures, administered the functional performance tests.

Before and during each session, participants were observed for dizziness, excessive fatigue, foot pain, skin irritation, and other symptoms that could interfere with safe exercise. The walking environment was inspected before every session. When discomfort or other health concerns arose, the supervisor determined whether to interrupt or adjust exercise. Attendance was recorded for all scheduled sessions, with a mean attendance of $85.8 \pm 10.11\%$ in the barefoot group.

Outcome measures

Body composition and waist circumference

Body composition was measured using an InBody 770 bioelectrical impedance analyzer (InBody Co., Ltd., Republic of Korea), with the analyzed variables including body fat mass, percent body fat, skeletal muscle mass, and body mass index (BMI).

Waist circumference was assessed using a non-stretch tape placed horizontally at the midpoint between the top of the iliac crest and the lower margin of the last palpable rib. A single measurement was obtained at the end of a normal expiration and recorded to the nearest 0.1 cm.

Mobility-related functional outcomes

Trained assessors evaluated functional performance using standardized field-testing procedures. Left- and right-hand grip strength were measured with a BS-HG device (InBody Co., Ltd., Republic of Korea), while flexibility was assessed using a sit-and-reach test with a BS-FF device (InBody Co., Ltd., Republic of Korea).

Lower-body functional strength was assessed using the 30-s Chair Stand Test [10]. Using a chair approximately 40 cm high, participants began seated in its center with their arms crossed over the chest. After the examiner explained and demonstrated the movement, participants completed practice repetitions. One test trial was performed, recording the number of complete standing repetitions within 30 s.

Functional aerobic endurance was evaluated using the 2-min Step Test [11]. The target knee height was set at the midpoint between the middle of the patella and the top of the iliac crest. Participants stepped in place for 2 min, counting only repetitions that reached the designated knee height.

Functional mobility was assessed using the Timed Up and Go (TUG) test. Participants began seated in a chair, rose at the start signal, walked to a cone positioned 3 m in front of the chair, turned around the cone, returned, and sat down. One trial was performed, and the interval from standing to sitting again was recorded in seconds.

Coordination and complex directional walking performance were evaluated using the National Fitness 100 Figure-of-8 Walking Test protocol for older adults, consistent with a published description of this specific course configuration [12]. A rectangular area measuring 3.6 m × 1.6 m was marked on the floor, with cones placed at the two rear corners and a chair positioned centrally at the front, approximately 2.4 m from the cones. Participants began at the chair and walked around the right rear cone before returning to sit down; they then walked around the left rear cone and sat down again without resting. This sequence was repeated twice. One trial was conducted, and the total completion time was recorded in seconds.

Blood pressure and blood biochemical markers

Blood samples were collected from the antecubital vein after a fasting period of at least 9 h. The analyzed variables included fasting plasma glucose, total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and triglycerides. Blood lipid concentrations were measured using a CardioChek Plus (PTS Diagnostics, USA), while glucose was measured with a GlucoDr.auto AGM-4000 (All Medicus, Republic of Korea).

Resting blood pressure was assessed using a HEM-907 device (Omron Healthcare Co., Ltd., Japan). Heart rate was monitored before assessment, and once it reached 60–80 beats/min, blood pressure was measured on the left arm. Systolic and diastolic blood pressure were each recorded from a single measurement.

Barefoot walking intervention

The supervised barefoot walking program was conducted three times per week for 10 weeks. Each session included a 5-min warm-up, 30–40 min of barefoot walking, and a 5-min cool-down. Walking duration, perceived intensity, and surface demands were progressively increased to support gradual adaptation.

During weeks 1–3, participants walked on soft sand at a rating of perceived exertion (RPE) of 9–11. Sand walking continued during weeks 4–6, when combined sand-and-gravel surfaces were gradually introduced. During weeks 7–10, a greater proportion of walking took place on combined sand-and-gravel surfaces, with intensity increasing to an RPE of 12–14. The control group maintained its usual lifestyle and received no structured exercise program. Table 2 summarizes the intervention schedule, and Fig. 2 shows representative program settings.

Table 2
Structure and progression of the 10-week barefoot walking program

Phase	Frequency	Walking surface	Session structure	Intensity
Weeks 1–3	3 sessions/week	Barefoot walking on soft sand	5-min warm-up + 30–40-min walking + 5-min cool-down	RPE 9–11
Weeks 4–6	3 sessions/week	Sand, with gradual introduction of combined sand-and-gravel surfaces	5-min warm-up + 30–40-min walking + 5-min cool-down	Gradually increased
Weeks 7–10	3 sessions/week	Barefoot walking on combined sand-and-gravel surfaces	5-min warm-up + 30–40-min walking + 5-min cool-down	RPE 12–14

RPE, rating of perceived exertion.

Statistical analysis

An a priori sample-size calculation was performed using G*Power software (version 3.1.9.7; Heinrich-Heine-University, Düsseldorf, Germany), with an effect size of Cohen's $f = 0.40$, $\alpha = 0.05$, and statistical power = 0.80. Data were analyzed using IBM SPSS Statistics version 31.0 (IBM Corp., Armonk, NY, USA), with continuous variables presented as mean $\pm$ standard deviation. The main effects of Group and Time and the Group $\times$ Time interaction effects were evaluated using a two-way repeated-measures analysis of covariance (ANCOVA). Age was controlled for as the primary covariate to account for its well-established confounding influence on physical functional outcomes and body composition in older adults. Statistical significance was set at $p < 0.05$, and effect sizes are reported as partial eta squared (partial η^2).

Absolute standardized mean differences were used to describe the baseline imbalance. Because allocation was non-randomized and baseline age differed between groups, the interpretation of intervention-related effects focused on Group $\times$ Time interactions rather than Group main effects. Missing values were not imputed; analyses were conducted using participants with available complete pre-post data for each outcome, and no intention-to-treat analysis was performed.

Use of generative AI

OpenAI ChatGPT (GPT-5.6 Sol) was used solely to assist in creating and refining the participant flow diagram (Fig. 1). The authors reviewed and revised the resulting content and take full responsibility for the final figure and manuscript.

Results

Participant flow, baseline characteristics, and attendance

Of 30 enrolled participants, 25 completed the study and were included in the final analysis: barefoot-walking group, 12 participants; control group, 13 participants (Fig. 1). The barefoot-walking group had a mean attendance of $85.8 \pm 10.11\%$ and was younger than the control group at baseline (66.50 ± 5.20 vs. 71.38 ± 3.25 years; absolute standardized mean difference [SMD] = 1.138). Descriptive imbalances were also evident in body mass index (23.26 ± 2.57 vs. 25.85 ± 3.48 kg/m²; absolute SMD = 0.843) and height (162.80 ± 8.21 vs. 156.16 ± 11.15 cm; absolute SMD = 0.674) in the barefoot-walking and control groups, respectively, indicating that between-group differences must be interpreted in the context of baseline imbalance (Table 1).

Body composition and waist circumference

Age-adjusted repeated-measures analysis of covariance identified Group $\times$ Time interactions for body fat mass ($F = 5.813$, $p = 0.025$, partial $\eta^2 = 0.209$; 95% CI, -2.62 to -0.20), percent body fat ($F = 4.800$, $p = 0.039$, partial $\eta^2 = 0.179$; 95% CI, -3.94 to -0.11), and waist circumference ($F = 9.830$, $p = 0.005$, partial $\eta^2 = 0.309$; 95% CI, -8.94 to -1.82). In the barefoot group, body fat mass changed from 17.42 ± 4.99 to 17.38 ± 5.72 kg, whereas that in the control group changed from 23.18 ± 5.45 to 24.22 ± 5.34 kg. Waist circumference decreased from 81.88 ± 8.61 to 80.50 ± 8.17 cm in the barefoot group but increased from 86.46 ± 10.77 to 91.15 ± 11.02 cm in the controls. No significant Group $\times$ Time interaction was identified for skeletal muscle mass ($p = 0.468$) or BMI ($p = 0.131$). Because group main effects reflected pre-existing differences, we did not interpret them as intervention effects (Table 3).

Table 3

Changes in body composition and waist circumference before and after the 10-week intervention

Variable	Group	Pre	Post	Effect	F	Partial η^2
Body fat mass (kg)	Barefoot walking	17.42 $\pm$ 4.99	17.38 $\pm$ 5.72	Group	8.036**	.268
	Control	23.18 $\pm$ 5.45	24.22 $\pm$ 5.34	Time	1.556	.066
				Group $\times$ Time	5.813*	.209
Percent body fat (%)	Barefoot walking	28.12 $\pm$ 6.45	27.87 $\pm$ 7.11	Group	14.690***	.400
	Control	36.79 $\pm$ 6.21	38.11 $\pm$ 6.26	Time	1.102	.048
				Group $\times$ Time	4.800*	.179
Skeletal muscle mass (kg)	Barefoot walking	24.33 $\pm$ 4.72	24.48 $\pm$ 4.27	Group	3.195	.127
	Control	21.41 $\pm$ 5.69	21.41 $\pm$ 5.86	Time	0.494	.022
				Group $\times$ Time	0.545	.024
BMI (kg/m ²)	Barefoot walking	23.26 $\pm$ 2.57	23.29 $\pm$ 2.48	Group	6.743*	.235
	Control	25.85 $\pm$ 3.48	26.06 $\pm$ 3.37	Time	0.425	.019
				Group $\times$ Time	2.457	.100
Waist circumference (cm)	Barefoot walking	81.88 $\pm$ 8.61	80.50 $\pm$ 8.17	Group	2.326	.096
	Control	86.46 $\pm$ 10.77	91.15 $\pm$ 11.02	Time	0.410	.018
				Group $\times$ Time	9.830**	.309

Values are expressed as mean $\pm$ standard deviation unless otherwise indicated. F statistics and partial η^2 were derived from age-adjusted two-way repeated-measures ANCOVA. Partial η^2 denotes partial eta squared. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. ANCOVA, analysis of covariance; BMI, body mass index.

Mobility-related functional outcomes

Table 4 shows no significant Group $\times$ Time interaction for TUG ($F < 0.001$, $p = 0.996$, partial $\eta^2 < 0.001$), and the Time main effect was also not significant ($F = 0.032$, $p = 0.860$, partial $\eta^2 = 0.001$). Although scores for the 30-s Chair Stand Test and Figure-of-8 Walking Test changed numerically, significant Group $\times$ Time interactions were identified for both outcomes ($F = 6.606$, $p = 0.017$, partial $\eta^2 = 0.231$, and $F = 6.506$, $p = 0.018$, partial $\eta^2 = 0.228$, respectively; Table 4). Interaction effects for sit-and-reach performance ($p = 0.259$) and bilateral grip strength (left, $p = 0.390$; right, $p = 0.200$) were not identified as statistically significant (Table 4).

Table 4
Changes in mobility-related functional outcomes before and after the 10-week intervention

Variable	Group	Pre	Post	Effect	F	Partial η^2
30-s Chair Stand Test (repetitions)	Barefoot walking	21.83 $\pm$ 3.76	28.67 $\pm$ 3.92	Group	20.336***	.480
	Control	16.15 $\pm$ 3.65	17.77 $\pm$ 4.30	Time	3.028	.121
				Group $\times$ Time	6.606*	.231
2-min Step Test (repetitions)	Barefoot walking	113.33 $\pm$ 8.03	126.33 $\pm$ 10.68	Group	31.505***	.589
	Control	95.85 $\pm$ 13.37	91.00 $\pm$ 13.67	Time	0.391	.017
				Group $\times$ Time	15.878***	.419
Sit-and-reach (cm)	Barefoot walking	8.16 $\pm$ 9.75	11.63 $\pm$ 8.11	Group	0.741	.033
	Control	9.75 $\pm$ 12.12	10.52 $\pm$ 10.29	Time	0.025	.001
				Group $\times$ Time	1.342	.057
TUG (s)	Barefoot walking	5.33 $\pm$ 0.65	5.02 $\pm$ 0.59	Group	29.805***	.575
	Control	7.83 $\pm$ 1.47	7.54 $\pm$ 1.10	Time	0.032	.001
				Group $\times$ Time	< .001	< .001
Figure-of-8 Walking Test (s)	Barefoot walking	22.93 $\pm$ 2.43	19.39 $\pm$ 2.63	Group	15.380***	.411
	Control	27.78 $\pm$ 3.19	26.78 $\pm$ 3.92	Time	0.835	.037
				Group $\times$ Time	6.506*	.228
Grip strength, left (kg)	Barefoot walking	29.83 $\pm$ 7.20	30.75 $\pm$ 7.95	Group	5.818*	.209
	Control	22.90 $\pm$ 6.48	23.07 $\pm$ 8.11	Time	0.279	.013

Variable	Group	Pre	Post	Effect	F	Partial η^2
				Group $\times$ Time	0.770	.034
Grip strength, right (kg)	Barefoot walking	30.59 $\pm$ 8.56	32.74 $\pm$ 8.80	Group	3.625	.141
	Control	24.25 $\pm$ 7.11	24.55 $\pm$ 8.98	Time	< .001	< .001
				Group $\times$ Time	1.744	.073

Values are expressed as mean $\pm$ standard deviation unless otherwise indicated. *F* statistics and partial η^2 were derived from an age-adjusted two-way repeated-measures ANCOVA. TUG denotes Timed Up and Go, and partial η^2 denotes partial eta squared. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. ANCOVA, analysis of covariance; TUG, Timed Up and Go.

Blood pressure and blood biochemical markers

No significant Group $\times$ Time effects were found for systolic blood pressure ($p = 0.062$), diastolic blood pressure ($p = 0.491$), fasting plasma glucose ($p = 0.361$), total cholesterol ($p = 0.265$), HDL-C ($p = 0.372$), LDL-C ($p = 0.063$), or triglycerides ($p = 0.094$). Thus, none of the measured blood pressure or blood biochemical outcomes showed a clear intervention-related between-group difference (Table 5).

Table 5

Changes in blood pressure and blood biochemical markers before and after the 10-week intervention

Variable	Group	Pre	Post	Effect	F	Partial η^2
SBP (mmHg)	Barefoot walking	134.25 $\pm$ 12.08	134.75 $\pm$ 14.05	Group	< .001	< .001
	Control	143.00 $\pm$ 17.99	136.50 $\pm$ 12.92	Time	3.177	.131
				Group $\times$ Time	3.886	.156
DBP (mmHg)	Barefoot walking	80.67 $\pm$ 8.30	76.25 $\pm$ 5.17	Group	0.341	.016
	Control	77.75 $\pm$ 8.37	73.50 $\pm$ 6.36	Time	2.654	.112
				Group $\times$ Time	0.491	.023
Fasting plasma glucose (mg/dL)	Barefoot walking	114.00 $\pm$ 10.39	105.00 $\pm$ 11.61	Group	0.752	.035
	Control	106.83 $\pm$ 16.31	103.00 $\pm$ 18.04	Time	0.380	.018
				Group $\times$ Time	0.871	.040
Total cholesterol (mg/dL)	Barefoot walking	151.67 $\pm$ 42.68	172.67 $\pm$ 40.73	Group	0.166	.008
	Control	141.83 $\pm$ 36.63	153.17 $\pm$ 26.92	Time	0.683	.032
				Group $\times$ Time	1.314	.059
HDL-C (mg/dL)	Barefoot walking	55.42 $\pm$ 17.98	63.42 $\pm$ 16.94	Group	2.790	.117
	Control	53.00 $\pm$ 9.65	56.58 $\pm$ 12.09	Time	0.282	.013
				Group $\times$ Time	0.831	.038
LDL-C (mg/dL)	Barefoot walking	71.90 $\pm$ 47.86	97.20 $\pm$ 34.78	Group	0.053	.003
	Control	73.00 $\pm$ 35.10	68.27 $\pm$ 25.39	Time	0.669	.036

Variable	Group	Pre	Post	Effect	F	Partial η^2
				Group × Time	3.935	.179
Triglycerides (mg/dL)	Barefoot walking	121.17 ± 76.31	101.42 ± 33.46	Group	1.537	.068
	Control	118.75 ± 69.86	159.00 ± 70.14	Time	0.179	.008
				Group × Time	3.069	.128

Values are expressed as mean ± standard deviation unless otherwise indicated. *F* statistics and partial η^2 were derived from age-adjusted two-way repeated-measures ANCOVA. ANCOVA, analysis of covariance; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; partial η^2 , partial eta squared; SBP, systolic blood pressure.

Discussion

This non-randomized community-based study revealed a distinctly uneven response to 10 weeks of supervised barefoot walking. Age-adjusted Group × Time interactions emerged for functional aerobic endurance, lower-body functional strength, complex directional walking performance, body fat mass, percent body fat, and waist circumference, whereas blood pressure and blood biochemical markers showed no comparable pattern. Therefore, the principal finding is selectivity, as changes were confined to particular functional and anthropometric outcomes rather than extending across every measured health domain.

The 2-min Step Test provided the strongest functional signal. As a field measure of exercise capacity and functional aerobic endurance [11], this test captures a movement-related capacity directly relevant to maintaining mobility. Performance increased in the barefoot group and declined in the control group, producing the largest interaction effect among the functional outcomes. This pattern fits previous evidence that walking-based interventions benefit endurance more consistently than other dimensions of physical function [4]. Nonetheless, the barefoot group already performed better at baseline, and adjustment for age alone does not eliminate confounding introduced by non-randomized allocation. The finding is best interpreted as a change in mobility-related capacity rather than as a direct assessment of independence.

The anthropometric findings require a more nuanced interpretation. Body fat mass and percent body fat changed little within the barefoot group, with interaction effects driven largely by increases in the control group rather than by substantial fat loss among barefoot walkers. Waist circumference exhibited a clearer contrast, decreasing in the barefoot group while increasing in controls. Reviews of walking-based interventions likewise report variable changes in anthropometric measures and cardiovascular risk

indicators, depending on the population, intervention type, intensity, and exposure [13, 14]. Baseline differences in age, BMI, height, and body composition in the present study complicate attribution and leave room for residual confounding.

The remaining functional outcomes showed a mixed response. Chair-stand and Figure-of-8 performance changed numerically, and the corresponding Group $\times$ Time interactions were identified as statistically significant (Table 4). Despite differences in absolute performance between groups, the TUG also exhibited no significant interaction. That distinction matters in a non-randomized study, as a Group main effect describes a difference between groups rather than a response produced by the intervention. Blood pressure, fasting plasma glucose, and lipid measures were similarly unresponsive at the between-group level. Diet, medication use, sleep, and physical activity outside the program were not tightly controlled, and 10 weeks might have been too brief to reveal changes in some markers. Even so, the available data provide no basis for assuming that a longer or more intensive program would necessarily produce cardiometabolic benefits.

The functional pattern can be discussed in light of the tasks participants actually performed. Barefoot and shod walking differ in gait characteristics and lower-limb loading [5], whereas studies in older adults describe condition-specific differences in gait variability and balance recovery [7, 15]. Exercise demands may be further altered by surface compliance and irregularity [8]. Therefore, repeated supervised walking on sand and combined sand-and-gravel surfaces brought together aerobic activity, task repetition, and adaptation to changing environmental demands. Although this explanation is plausible, plantar sensation, foot strength, muscle activity, and gait biomechanics were not measured; none can be presented as an observed mechanism.

From an active-aging perspective, this study's practical contribution lies in testing a structured program within an existing outdoor community setting. Reviews of community-based physical activity support the value of locally delivered programs for mobility-related outcomes [2, 16], while environmental accessibility influences whether older adults can participate [9]. Although mean attendance was $85.8 \pm 10.11\%$, suggesting good adherence to the scheduled supervised sessions, this does not substitute for formal evidence of feasibility, safety, long-term adherence, or effectiveness in other settings. Individual foot health, surface conditions, and appropriate supervision deserve explicit attention when considering community implementation.

Some limitations dictate the appropriate interpretation. Because the final sample was small and allocation was not randomized, baseline imbalance and residual confounding were possible despite adjustment for age. Without a conventional shod-walking comparison group, barefoot exposure cannot be separated from walking itself, surface characteristics, or the supervised program context. The intervention period was relatively short, and factors such as diet, medication use, sleep, and additional physical activity were not fully controlled. Because multiple outcomes were examined without a confirmed multiplicity-adjustment procedure, the findings should be interpreted as exploratory. Finally,

independence, activities of daily living, and potential sensory or biomechanical mechanisms were not directly measured.

Future studies should use randomized controlled designs with larger samples and longer follow-up, incorporating a conventional shod-walking comparator matched as closely as possible for walking exposure and environmental conditions. Clear documentation of prespecified outcome priorities, participant retention, outcome-specific sample sizes, and verified adverse-event records would strengthen interpretation. Direct assessment of gait characteristics, relevant sensory variables, and daily functioning would also help distinguish practical functional relevance from potentially barefoot-specific mechanisms.

Conclusions

A 10-week community-based barefoot walking program corresponded to selective changes in functional aerobic endurance, lower-body functional strength, complex directional walking performance, body fat indicators, and waist circumference in older adults. Blood pressure, fasting plasma glucose, and lipid markers demonstrated no clear intervention-related response. Randomized controlled trials including a conventional shod-walking comparator are warranted.

Abbreviations

ANCOVA

Analysis of covariance

BMI

Body mass index

DBP

Diastolic blood pressure

HDL-C

High-density lipoprotein cholesterol

LDL-C

Low-density lipoprotein cholesterol

RPE

Rating of perceived exertion

SBP

Systolic blood pressure

SMD

Standardized mean difference

TUG

Timed Up and Go.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Andong National University (protocol code 1040191-202408-BR-003-01; date of approval: 20 August 2024). Written informed consent to participate was obtained from all participants. The study was retrospectively registered with the Clinical Research Information Service (CRIS), Korea Disease Control and Prevention Agency, National Institute of Health (registration number: KCT0012556; date of registration: 4 September 2026).

Consent for publication

Not applicable. Figure 2 depicts walking-surface textures only and contains no identifiable individuals or personal data.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

AK, MC and H-SS conceived and designed the study. AK, MC and H-SS developed the methodology. MC developed the software used for analysis. MC, HY and H-SS validated the results. MC performed the formal analysis. AK, DAK, MK and HY conducted the investigation. HY and H-SS provided resources. AK, DAK and MK curated the data. AK wrote the original draft. AK, MC and H-SS reviewed and edited the manuscript. MC and DAK prepared the visualizations. AK and H-SS supervised the project. MC and MK administered the project. All authors read and approved the final manuscript.

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Data Availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request. The data are not publicly available owing to privacy and ethical considerations.

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Figures

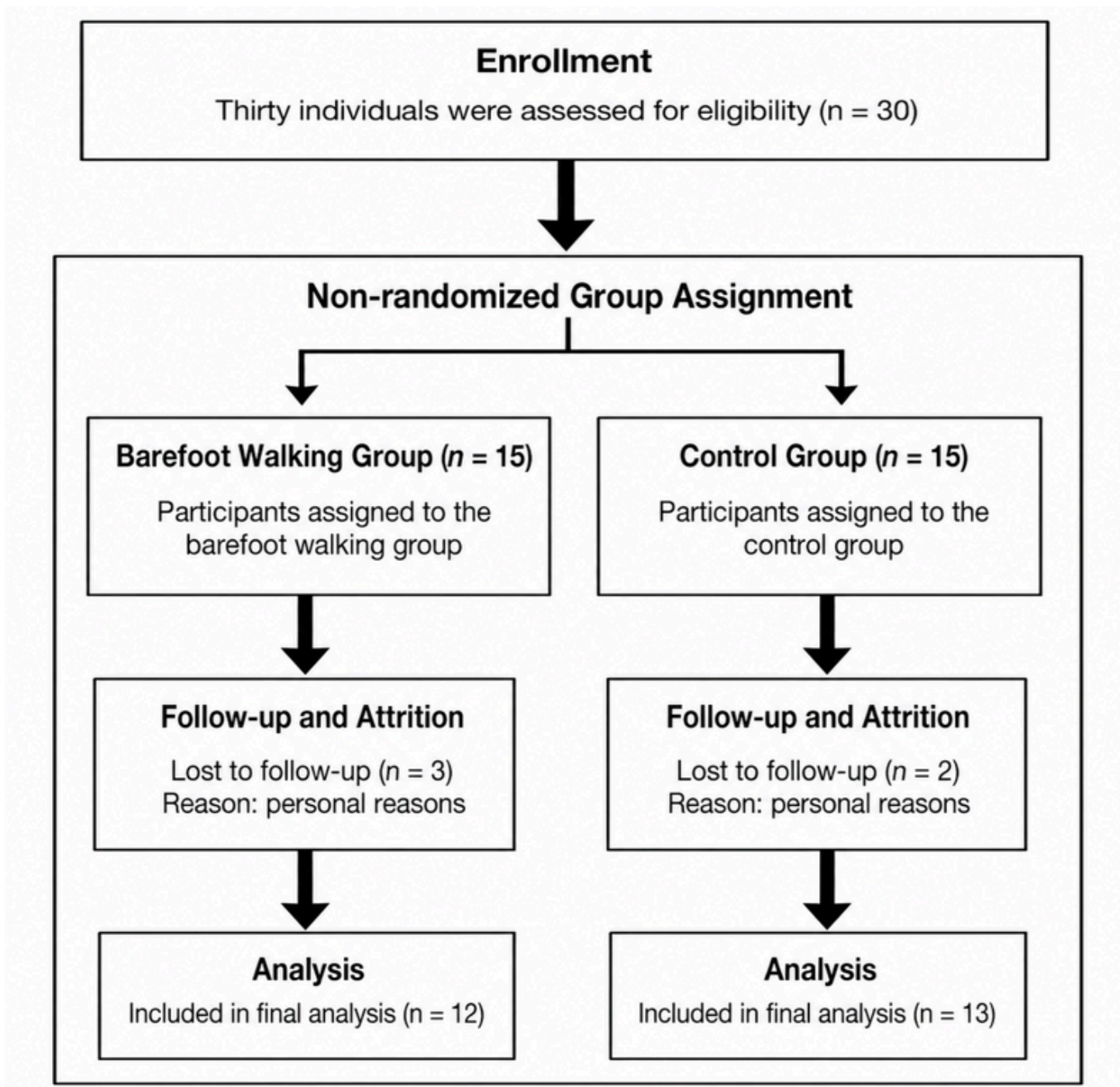


Figure 1

Participant flow through enrollment, non-randomized group allocation, follow-up, and final analysis.

(A) soft sand



(B) sand-and-gravel



Figure 2

Representative walking surfaces used in the barefoot walking program: (A) soft sand used during the initial phase (weeks 1–3); (B) combined sand-and-gravel surface introduced during later phases (weeks 4–10).