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Increased Daily Step Count Benefits Lung Function: A Repeated Measure Panel Study in Guangzhou, China

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Abstract

Background: Daily step count was associated with various health outcomes. However, the quantitative relationship between daily step count and lung function among general population is unclear to date.

Methods: We conducted a panel study with repeated measurement of daily step counts and lung function parameters in consecutive 11 days among 16 healthy male college students in a self-controlled study design. Linear mixed-effect model was used to assess the dose-response relationship between daily step count and lung function parameters.

Results: Compared with control days, subjects in intervention days had lower daily step counts and lung function parameters. Nonlinear associations of daily step count with $FEV_{0.5}$, $FEV_{0.5}$/FVC, and $FEV_{1.0}$/FVC were observed in all observations, but become insignificant in subgroups of step count ≤ 8000 or >8000. Significant linear dose-response relationships were observed in those taking daily step counts ≤ 8000, showing that each 1000-increase in daily step was significantly associated with 36.81 ml, 20.29 ml, 1.36%, 0.48%, 1.88%, 1.38%, 2.06% and 0.76% increase in $FEV_{0.5}$, $FEV_{1.0}$, $FEV_{0.5}$/FVC, $FEV_{1.0}$/FVC, $MMF\%_{pred}$, $FEF25\%_{pred}$, $FEF50\%_{pred}$, and $FEF75\%_{pred}$, respectively.

Conclusion: Increased daily step count benefits lung function among healthy male adults, though the excess benefit was limited when taking more than 8000 steps per day.

Keywords: Daily step count • Lung function • Dose-response relationship • Healthy male adults • Linear mixed-effect model

Abbreviations: FVC: Forced Vital Capacity; $FEV_{0.5}$: Forced Expiratory Volume in 0.5 second; $FEV_{1.0}$: Forced Expiratory Volume in 1 second; MMF: Maximal Mid-Expiratory Flow; FEF_{25}: Forced Expiratory Flow after 25% of vital capacity; FEF_{50}: Forced Expiratory Flow after 50% of vital capacity; FEF_{75}: Forced Expiratory Flow after 75% of vital capacity; BMI: Body Mass Index; COPD: Chronic obstructive Pulmonary Disease; 95% CI: 95% Confident Interval.

Introduction

Benefits of walking appear to increase in line with physical activity [1]. On the basis of epidemiologic and clinical studies, significant health benefits have been observed from increased daily step count, but the evidence for the recommendation of steps per day is limited and inconsistent [2,3]. For example, a previous study among US adults reported the lowest all-cause mortality rate of step can accrue through accumulation of 12000 steps and suggested at least taking 8000 steps per day, though a reasonable target of 10000 steps per day had been promoted [5].

Besides long-term health benefits including prevention and management of non-communicable diseases, and lowering risk of mortality, increasing daily step count can also have immediate benefits such as heart rate, blood pressure and lipid metabolism improvement, as well as lung function [7]. Although previous studies reported that taking more step counts were associated with greater lung function, most have solely been conducted in older adults or individuals with chronic respiratory diseases, which limited the generalizability of those findings. The benefit of increased daily step count for lung function improvement is less clear among healthy adults [8].

To fill the gap, we conducted a panel study with daily step intervention in Guangzhou, China to assess the benefits for lung function from increased daily step count. We also quantitatively assessed the dose-response associations between daily step count and lung function parameters and tried to identify the recommended daily step target for lung function improvement among healthy male adults [9-12].

Materials and Methods

Study population and design

We conducted a panel study among 16 healthy male subjects who were college students recruited from Guangzhou Medical University, and fulfil the inclusion criteria:

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Table 1. Characteristics of daily step count and lung function parameters in intervention days and control days.

- Had no cardiopulmonary diseases.
- Nonsmoker.
- Nondrinker.
- No drug use in the past one month.

All subjects were collected information on demographic and socioeconomics by a face-to-face interview using a standardized questionnaire [13]. The study was conducted in 11 consecutive days (from November 21, 2020 to December 1, 2020) including two weekends. This was a self-controlled study design and each subject was served as his own control during the period. We requested all the subjects to stay in their dormitory rooms on the weekends to perform an intervention on daily step count (intervention days), and no interventions were made on weekdays (*i.e.*, control days). Daily step count and lung function were measured each day during the study period. The institutional review boards at Guangzhou Medical University approved the protocol prior to study initiation and all subjects provided written informed consent [14].

Daily step count measurement

Daily step count data of each subject were objectively obtained by a smart sport bracelet (HUAWEI Honor Band 5i, Huawei Technologies Co., Ltd., and Shenzhen, China). We had tested the association between five-minute step counts recorded by HUAWEI Honor Band 5i and manual counts, showing a high accuracy of the devices (N=16, coefficient of determination=0.94). All the subjects were requested to wear the devices during the whole study period [15].

Lung function test

Each subject was tested lung function at the same time of day (*i.e.*, 7:00-8:00 pm) using an electronic spirometer (Chestgraph HI-101, CHEST Ltd., Tokyo, Japan). Subjects were asked to perform at least three maneuvers of forced expiratory lung function to obtain acceptable and reproducible results. The procedure was in accordance with the American thoracic society recommendations on lung function test. Lung function parameters including Forced Expiratory Volume in 0.5 second ($FEV_{0.5}$), Forced Expiratory Volume in 1 second (FEV_1), Forced Vital Capacity (FVC), Maximal Mid-Expiratory Flow (MMF) and Forced Expiratory Flow (FEF_{25}, FEF_{50}, FEF_{75}) were recorded. The percentages of predicted values of MMF ($MMF\%_{pred}$) and FEF ($FEF25\%_{pred}$, $FEF50\%_{pred}$ and $FEF75\%_{pred}$), which were further considering the confounders such as race, age, height and weight, were also included into the main analyses [16].

Statistical analysis

We divided all the observations into two categories, including 0 to 8000 (low), and over 8000 (high) step counts per day. The cut-off point of 8000 step referred to the previous studies. We used t-test and Wilcoxon test to compare the daily step count and lung function parameters between intervention days and control days, as well as the lung function between low and high levels of daily step count. We also pooled the mean change in lung function parameters of each subject after intervention compared to the control [17].

The linear mixed-effect model was applied to assess the effect of intervention on lung function which was presented by percent change of each parameter compared to the control, and to estimate the dose-response relationship between daily step count and lung function. For measured values and ratios of lung function parameters (*i.e.*, FVC, $FEV_{0.5}$, $FEV_{1.0}$, $FEV_{0.5}$/FVC and $FEV_{1.0}$/FVC), models were adjusted for between-subject covariates including age, height, Body Mass Index (BMI), but not for percentage of predicted values of lung function parameters (*i.e.*, $MMF\%_{pred}$, $FEF25\%_{pred}$, $FEF50\%_{pred}$ and $FEF75\%_{pred}$), due to the predicted values were estimated under consideration of those covariates. Subgroup analyses of lung function parameters enrolled in each step count groups were conducted using an identical model. We report mean and 95% CI of changes in each lung function parameter associated with each 1000 step counts change [18].

In addition, we included daily step count with a natural cubic spline function (degrees of freedom=3) in the models to plot exposure-response curves and examine potential nonlinear associations using likelihood ratio tests. For low and high step count groups, both linear and nonlinear associations were evaluated. All P values were two-sided and a P value less than 0.05 were considered statistically significant. All the analyses were conducted in R (version 4.1.1, RRID: SCR_001905) within the RStudio (version 1.4.1717, RRID: SCR_000432) platform.

Results

There were 16 subjects with 176 observations in the study period of 11 consecutive days. All the subjects were male and aged from 19.1 to 22.7 years (mean: 21.2 years). The mean values for height and BMI were 170.0 cm and 21.0 kg/m^2. Compared with control days, subjects in intervention days had lower daily step counts and lung function parameters (Table 1), where there were 6.02% (95% CI, 3.09, 8.95), 2.15% (95% CI, 0.91, 3.39), 6.67% (95% CI, 3.44, 9.92), 1.91% (95% CI, 0.81, 3.03), 7.92% (95% CI, 3.74, 12.10), 8.96% (95% CI, 3.36, 14.55) and 8.21% (95% CI, 2.94, 13.48) decline in $FEV_{0.5}$, $FEV_{1.0}$, $FEV_{0.5}$/FVC, $FEV_{1.0}$/FVC, $MMF\%_{pred}$, $FEF25\%_{pred}$ and $FEF50\%_{pred}$ respectively and each subject presented a nearly consistent downward trend. In subgroups of low and high step count, taking over 8000 step per day had higher level in FVC, $FEV_{0.5}$ and $FEV_{1.0}$ (Table 2).

Parameters	Study period				P value a	P value b
	Intervention (n=64)		Control (n=112)			
	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)		
Daily step count (step)	1708.00 (4469.00)	3580.06 (3722.71)	8348.50 (4549.00)	9485.900 (4444.84)	<0.01	<0.01
FVC (ml)	3920.00 (770.00)	3881.43 (635.87)	3940.00 (765.00)	3839.64 (642.32)	0.78	0.68
$FEV_{0.5}$ (ml)	2570.00 (650.00)	2431.91 (522.05)	2655.00 (435.00)	2597.68 (433.24)	0.05	0.04
$FEV_{1.0}$ (ml)	3400.00 (570.00)	3404.13 (547.98)	3575.00 (608.00)	3460.00 (548.84)	0.39	0.52
$FEV_{0.5}$/FVC (%)	64.67 (14.45)	62.92 (11.19)	67.75 (10.89)	68.02 (8.52)	<0.01	<0.01
$FEV_{1.0}$/FVC (%)	88.89 (8.97)	87.94 (6.50)	90.19 (6.66)	90.41 (5.15)	0.02	0.01
$MMF\%_{pred}$ (%)	74.30 (27.60)	73.62 (19.07)	78.85 (23.00)	79.08 (17.28)	0.05	0.06
$FEF25\%_{pred}$ (%)	71.60 (39.40)	68.56 (21.82)	79.70 (26.00)	76.14 (17.83)	0.05	0.02
$FEF50\%_{pred}$ (%)	70.10 (30.20)	72.48 (21.81)	76.65 (26.50)	78.58 (19.77)	0.04	0.07
$FEF75\%_{pred}$ (%)	69.30 (20.20)	68.30 (17.39)	70.25 (23.00)	70.30 (18.43)	0.56	0.48

Note: FVC: Forced Vital Capacity; $FEV_{0.5}$: Forced Expiratory Volume in 0.5 Second; $FEV_{1.0}$: Forced Expiratory Volume in 1 Second; MMF: Maximal Mid-Expiratory Flow; FEF_{25}: Forced Expiratory Flow After 25% of Vital Capacity; FEF_{50}: Forced Expiratory Flow After 50% of Vital Capacity; FEF_{75}: Forced Expiratory Flow After 75% of Vital Capacity. a. P value for Wilcoxon test. b. P value for t-test.

Table 1. Characteristics of daily step count and lung function parameters in intervention days and control days.

Lung function parameters	Daily step count levels (n=176)		P value
	Low (0-8000)	High (>8000)	
	n=106	n=70	
FVC (ml)	1708.00 (4469.00)	8348.50 (4549.00)	<0.01
$FEV_{0.5}$ (ml)	3920.00 (770.00)	3940.00 (765.00)	0.78
$FEV_{1.0}$ (ml)	2570.00 (650.00)	2655.00 (435.00)	0.05
$FEV_{0.5}$/FVC (%)	3400.00 (570.00)	3575.00 (608.00)	0.39
$FEV_{1.0}$/FVC (%)	64.67 (14.45)	67.75 (10.89)	<0.01
$MMF\%_{pred}$ (%)	88.89 (8.97)	90.19 (6.66)	0.02
$FEF25\%_{pred}$ (%)	74.30 (27.60)	78.85 (23.00)	0.05
$FEF50\%_{pred}$ (%)	71.60 (39.40)	79.70 (26.00)	0.05
$FEF75\%_{pred}$ (%)	70.10 (30.20)	76.65 (26.50)	0.04

Note: FVC: Forced Vital Capacity; $FEV_{0.5}$: Forced Expiratory Volume In 0.5 Second; $FEV_{1.0}$: Forced Expiratory Volume In 1 Second; MMF: Maximal Mid-Expiratory Flow; FEF_{25}: Forced Expiratory Flow After 25% of Vital Capacity; FEF_{50}: Forced Expiratory Flow After 50% of Vital Capacity; FEF_{75}: Forced Expiratory Flow After 75% of Vital Capacity.

Table 2. Characteristics of lung function parameters in low and high levels of daily step

Table 3 presents the linear associations between daily step count and lung function parameters. We found that each 1000 increase in daily step count was significantly associated with 13.00 ml (95% CI, 4.75, 21.26), 7.06 ml (95% CI, 2.39, 11.73), 0.30% (95% CI, 0.08, 0.52), 0.13% (95% CI, 0.02, 0.24), 0.55% (95% CI, 0.20, 0.24), 0.69% (95% CI, 0.23, 1.14) and 0.53% (95% CI, 0.10, 0.97) increase in $FEV_{0.5}$, $FEV_{1.0}$, $FEV_{0.5}$/FVC, $FEV_{1.0}$/FVC, $MMF\%_{pred}$, $FEF25\%_{pred}$ and $FEF50\%_{pred}$, respectively. We found nonlinear associations for $FEV_{0.5}$, $FEV_{0.5}$/FVC, and $FEV_{1.0}$/FVC in the models including daily step count as natural cubic spline function (all P values for nonlinear trend <0.05, (Figure 1).

Lung function parameters	Each 1000-increase in daily step count (n=176)	
	β (95% CI)	P value
FVC (ml)[a]	0.22 (-3.28, 3.73)	0.9
$FEV_{0.5}$ (ml)[a]	13.00 (4.75, 21.26)	<0.01
$FEV_{1.0}$ (ml)[a]	7.06 (2.39, 11.73)	<0.01
$FEV_{0.5}$/FVC (%)[a]	0.30 (0.08, 0.52)	<0.01
$FEV_{1.0}$/FVC (%)[a]	0.13 (0.02, 0.24)	0.02
$MMF\%_{pred}$ (%)[b]	0.55 (0.20, 0.24)	<0.01
$FEF25\%_{pred}$ (%)[b]	0.69 (0.23, 1.14)	<0.01
$FEF50\%_{pred}$ (%)[b]	0.53 (0.10, 0.97)	0.02
$FEF75\%_{pred}$ (%)[b]	0.12 (-0.15, 0.38)	0.4

Note: FVC: Forced Vital Capacity; $FEV_{0.5}$: Forced Expiratory Volume In 0.5 Second; $FEV_{1.0}$: Forced Expiratory Volume In 1 Second; MMF: Maximal Mid-Expiratory Flow; FEF_{25}: Forced Expiratory Flow After 25% of Vital Capacity; FEF_{50}: Forced Expiratory Flow After 50% of Vital Capacity; FEF_{75}: Forced Expiratory Flow After 75% of Vital Capacity. a. Model 1 is adjusted for age (year), height (cm), body mass index (kg/m^2). b. Model 2 is crude model which is not adjusted for covariates included in model 1.

Table 3. Dose-response relationship between daily step count and lung function.

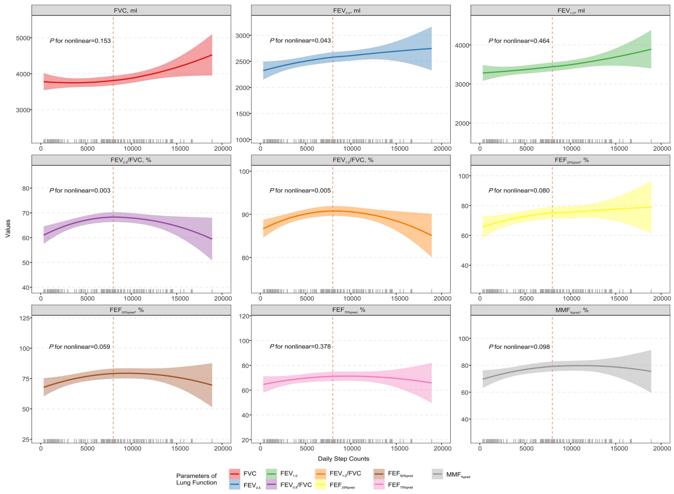

Figure 1. Exposure-response relationship between daily step count and lung function.

In subgroups of low and high step count, we found no significant nonlinear associations between daily step count and lung function parameters when daily step counts equal or less than 8000 (all P values for nonlinear trend >0.05). Each 1000 increase in daily step count were significantly associated with 36.81 ml (95% CI, 13.55, 60.08), 20.29 ml (95% CI, 8.91, 31.68), 1.36% (95% CI, 0.67, 2.05), 0.48% (95% CI, 0.18, 0.78), 1.88% (95% CI, 0.91, 2.84), 1.38% (95% CI, 0.12, 2.64), 2.06% (95% CI, 0.88, 3.24) and 0.76% (95% CI, 0.02, 1.50) increase in $FEV_{0.5}$, $FEV_{1.0}$, $FEV_{0.5}$/FVC, $FEV_{1.0}$/FVC, $MMF\%_{pred}$, $FEF25\%_{pred}$, $FEF50\%_{pred}$ and $FEF75\%_{pred}$ respectively (all p<0.05, Table 4). No significant nonlinear associations were observed when daily step counts over 8000 (all P>0.05).

Lung function parameters	Each 1000-increase in daily step count (n=176)			
	Low (0-8000)		High (>8000)	
	n=106		n=70	
	β (95% CI)	P value	β (95% CI)	P value
FVC (ml)[a]	-8.01 (-18.52, 2.23)	0.13	2.87 (-2.95, 8.69)	0.33
$FEV_{0.5}$ (ml)[a]	36.81 (13.55, 60.08)	0.002	4.94 (-4.59, 14.48)	0.31
$FEV_{1.0}$ (ml)[a]	20.29 (8.91, 31.68)	<0.001	3.16 (-2.86, 9.18)	0.3
$FEV_{0.5}$/FVC (%)[a]	1.36 (0.67, 2.05)	<0.001	0.04 (-0.18, 0.26)	0.71
$FEV_{1.0}$/FVC (%)[a]	0.48 (0.18, 0.78)	0.002	0.01 (-0.11, 0.13)	0.9
$MMF\%_{pred}$ (%)[b]	1.88 (0.91, 2.84)	<0.001	0.23 (-0.20, 0.67)	0.29
$FEF25\%_{pred}$ (%)[b]	1.38 (0.12, 2.64)	0.03	0.22 (-0.21, 0.65)	0.32
$FEF50\%_{pred}$ (%)[b]	2.06 (0.88, 3.24)	<0.001	0.16 (-0.45, 0.78)	0.6
$FEF75\%_{pred}$ (%)[b]	0.76 (0.02, 1.50)	0.04	0.29 (-0.07, 0.65)	0.12

Note: FVC: Forced Vital Capacity; $FEV_{0.5}$, Forced Expiratory Volume In 0.5 Second; $FEV_{1.0}$: Forced Expiratory Volume In 1 Second; MMF: Maximal Mid-Expiratory Flow; FEF_{25}: Forced Expiratory Flow After 25% of Vital Capacity; FEF_{50}: Forced Expiratory Flow After 50% of Vital Capacity; FEF_{75}: Forced Expiratory Flow After 75% of Vital Capacity. a. Model 1 is adjusted for age (year), height (cm), body mass index (kg/m^2). b. Model 2 is crude model which is not adjusted for covariates included in Model 1.

Table 4. Dose-response relationship between daily step count and lung function in subgroup analysis.

Discussion

In this panel study, we found benefits for lung function from increased daily step count. More daily step counts were associated with higher lung function levels. Subjects in control days presented higher lung function parameters, except FVC and FEF75%pred. Taking 8000 steps per days might immediately and effectively improve lung function among healthy male adults.

A study on American patients with Chronic Obstructive Pulmonary Disease (COPD) modeled the quantitative relationship between daily step counts and $FEV1.0\%_{pred}$, but they did not estimate the upper threshold of benefit and therefore was unable to propose a recommendation of daily step counts. Two recent studies on association between physical activity and lung function stated that adults with walking behavior had higher values of FVC% pred and $FEV1.0\%_{pred}$, while sitting time was negatively associated with these two parameters [19]. The previous study also found that, compared with individuals who were sedentary, those who prefer walking had higher absolute values in FVC and $FEV_{1.0}$ [20]. Our results were consistent with those previous studies. However, most of studies were conducted among the elderly and did not demonstrate the quantitative relationship. This study confirms and extends previous research by quantifying the upper threshold benefits of lung function from increased daily step count, which indicates that health young adults who take recommended daily step count may achieve immediate benefits of lung function (Tables 5 and 6).

Table 5. Percent change in lung function parameters after intervention compared to the control.

Parameters	Change (95% CI)
FVC[a]	0.41 (-0.46, 1.28)
$FEV_{0.5}$[a]	-6.02 (-8.95, -3.09)
$FEV_{1.0}$[a]	-2.15 (-3.39, -0.91)
$FEV_{0.5}$/FVC[a]	-6.67 (-9.92, -3.44)
$FEV_{1.0}$/FVC	-1.91 (-3.03, -0.81)
$MMF\%_{pred}$[b]	-7.92 (-12.10, -3.74)
$MMF\%_{pred}$[b]	-8.96 (-14.55, -3.36)
$FEF50\%_{pred}$[b]	-8.21 (-13.48,
$FEF75\%_{pred}$[b]	-0.97 (-4.61, 2.67)

Note: FVC: Forced Vital Capacity; $FEV_{0.5}$: Forced Expiratory Volume In 0.5 Second; $FEV_{1.0}$: Forced Expiratory Volume In 1 Second; MMF: Maximal Mid-Expiratory Flow; FEF_{25}: Forced Expiratory Flow After 25% of Vital Capacity; FEF_{50}: Forced Expiratory Flow After 50% of Vital Capacity; FEF_{75}: Forced Expiratory Flow After 75% of Vital Capacity. a. Model 1 is adjusted for age (year), height (cm), body mass index (kg/m2). b. Model 2 is crude model which is not adjusted for covariates included in Model 1.

Table 6. Nonlinear associations between lung function and two levels of daily step count.

Each 1000-increase in daily step count (n=176)		
Lung function parameters	Low (0-8000) n=106	High (>8000) n=70
	P value for nonlinear[a]	P value for nonlinear[a]
FVC (ml)	0.37	0.25
$FEV_{0.5}$ (ml)	0.07	0.73
$FEV_{1.0}$ (ml)	0.24	0.84
$FEV_{0.5}$/FVC (%)	0.12	0.32
$FEV_{1.0}$/FVC (%)	0.38	0.12
$MMF\%_{pred}$ (%)	0.72	0.67
$FEF25\%_{pred}$ (%)	0.05	0.92
$FEF50\%_{pred}$ (%)	0.84	0.78
$FEF75\%_{pred}$ (%) 0	0.87	0.65

Note: FVC, forced vital capacity; $FEV_{0.5}$, forced expiratory volume in 0.5 second; $FEV_{1.0}$: forced expiratory volume in 1 second; MMF: maximal mid-expiratory flow; FEF_{25}: forced expiratory flow after 25% of vital capacity; FEF_{50}: forced expiratory flow after 50% of vital capacity; FEF_{75}: forced expiratory flow after 75% of vital capacity. a. For low and high step count groups, daily step count was included with a natural cubic spline function (degrees of freedom=3) in the models to examine potential nonlinear associations using likelihood ratio tests.

Although an analysis reported that there were no significant improvements in cardiorespiratory fitness for daily step counts accumulating to a high level, from what affecting obesity and fat distribution and reducing systemic inflammation, these mechanisms were associated with lung function benefits derived from step increase which indirectly demonstrated that these benefits by accumulating on steps in this study is valid. A prior study performed in the elderly with COPD suggested that FVC, $FEV_{1.0}$, and $FEV_{1.0}$/FVC had no significantly improvement after two years walking guide, likely due to the age-associated decline in lung function. Such lung function parameters were used to evaluate the elastance of lung and the level of small airway resistance to facilitate the diagnosis of pulmonary diseases. The patients with COPD had already presented pathological changes in the values of these parameters, while health adults were not. Therefore, more studies are warranted to confirm the potential biological mechanism in different population (Figure 2).

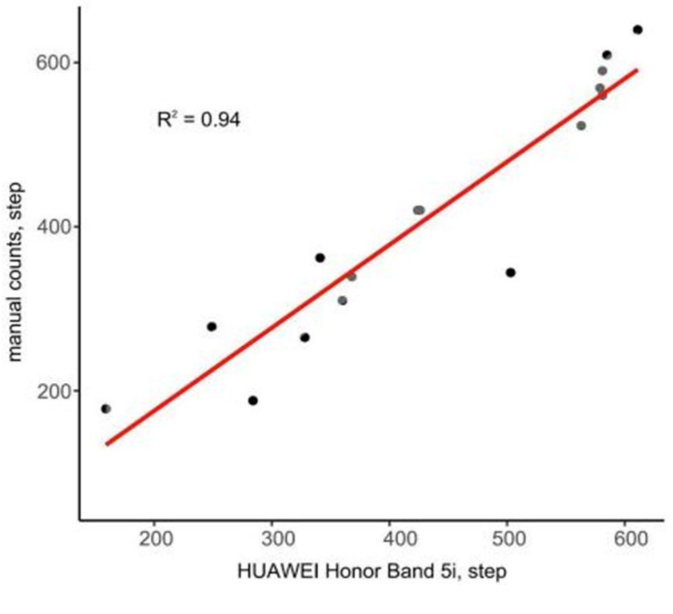

Figure 2. The correlation between five-minute step counts recorded by HUAWEI Honor Band 5i and manual counts.

These lung-related messages can strongly promote adults to strengthen routine physical activity because the ongoing respiratory dysfunction and respiratory diseases have posed significant challenges for the public health and health care system. Some institutions or organizations had set a recommended daily step count goal for adults and promoted it to the public, such as 10000 steps per day from official recommendation in Australia and Japan, and 8500 step from U.S. president's challenge physical activity and fitness awards program. Baseline steps per day of most studies were 5000, which was the maximum of spontaneous "background activity" of an ordinary adult. Taking extra step count up to 8000 or more through purposeful activity might counteract the adverse effect of sedentary time which had been increasing around the world. For 3000 or more steps increase per day, taking more stairs and fewer elevators is a simple and achievable goal, and we can also take walking as our first-mile and last-mile commute, rather than other mobility options. However, we cannot exclude the possibility of harm generated from physical activity, for instance, lung function declined due to outdoor air pollution, progression of osteoarthritis caused by greater daily step count (Figure 3).

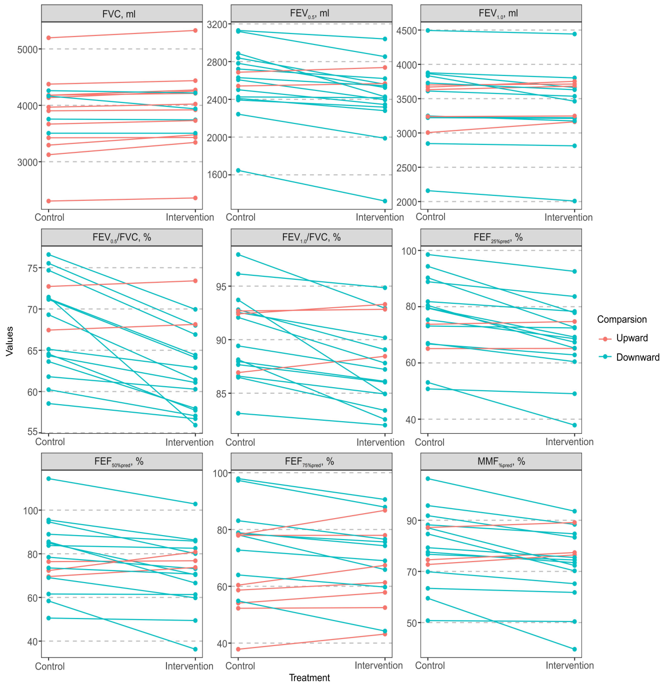

Figure 3. TMean change in lung function parameters of each subject after intervention

Strengths of our study included the effective intervention, repeated measurement data and stability of the result of each parameter. We had observed significant differences in lung function and daily step counts between intervention and control days. We used linear mixed-effect regression with repeated measurement data to generate the dose-response relationship between daily step count and lung function, for each 1000 step increased per day positively associating with the change of lung function parameters. Our subgroup analysis results strengthened our findings, indicating that there was an upper threshold of lung function benefit by increasing daily step counts among healthy adults. We further estimated recommended daily step count for adults and found that 8000 step per day being the threshold of benefit was consistent in the majority of parameters.

This study had several limitations. We did not assess the pace or intensity of step, both of which had showed association with physical health promotion and illness risk reduction. However, other studies indicated there was no association between step pace and mortality after considering daily step count. In addition, regarding to the results on the benefit of lung function from increased daily step, the generalization needs to be cautious due to our small-scale study subjects.

Conclusion

Our findings added new evidence that increased daily step count was significantly associated with higher lung function among young, healthy male adults. The dose-response relationships were linear when daily step counts equal or less than 8000. However, the excess benefit for lung function improvement from increased daily step count was limited when taking more than 8000 steps per day. Further studies are needed to confirm our results in other populations.

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Conflict of Interest

None declared.

Data Availability

The datasets generated during and analyzed during the current study are available from the corresponding author on reasonable request.

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Not applicable.

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