

OCCUPATIONAL DAILY WALKING STEPS HAVE INVERSE RELATIONSHIP WITH PAPILLARY THYROID CANCER RISK AND PROGRESSION: A RETROSPECTIVE ANALYSIS

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Abstract

Objectives: Investigate the impact of daily occupational walking steps on the progression of papillary thyroid cancer (PTC), a topic hitherto under-researched. **Material and Methods:** The authors analyzed the data from 800 individuals with PTC across stages 0–IV. Participants were evenly divided into 2 distinct occupational groups: office workers and construction workers (N = 400 each). Data included comprehensive records of daily walking steps, demographic information, and clinical indicators. Pearson's correlation coefficients or analysis of variance (ANOVA) were employed to assess the linkage between daily walking steps and PTC risk and stage, as well as associated biochemical markers. **Results:** The analysis revealed a significant inverse relationship between daily walking steps and PTC risk. A higher frequency of daily steps was associated with reduced chances of PTC onset and a lower diagnostic stage of the disease. This protective effect of physical activity was particularly pronounced in the construction worker cohort. Subsequent evaluations showed that construction workers who consistently logged higher daily steps had markedly lower levels of thyroid-stimulating hormone (TSH), free triiodothyronine, free thyroxine, thyroid peroxidase antibody, thyroglobulin antibody, and thyroglobulin (Tg). Notably, daily walking steps exhibited a strong inverse correlation with body mass index (BMI), age, PTC volumes, and levels of TSH and Tg across both occupational groups ($\rho < -0.37$). The increase in daily steps was associated with the reduction in PTC stages ($p < 0.001$). **Conclusions:** The research underscores the potential benefits of increased daily walking steps, suggesting that they may play a protective role in reducing PTC risk and moderating its progression. *Int J Occup Med Environ Health.* 2024;37(1):58–71

Key words:

biochemical markers, office workers, construction workers, papillary thyroid cancer, daily step counts, PTC stages

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INTRODUCTION

Papillary thyroid cancer (PTC), the most dominant type of thyroid cancer, constituting roughly 80–85% of all diagnosed cases. While there have been significant strides in diagnostic techniques and therapeutic measures, the global incidence rate of PTC continues to rise [1,2]. The underpinnings of PTC are multifaceted, with both genetic [3,4] and environmental factors [5,6]. Among the various risk factors, occupational physical activity level remains an intriguing aspect that warrants comprehensive exploration [5,7–9], but the effects of the activity on PTC remain seldom reported. There is a growing body of evidence supporting the notion that physical activity may play a protective role against various types of cancer [10,11]. Its definitive influence on PTC's onset and progression remains nebulous.

Modern occupational roles can largely be bifurcated into sedentary and physically demanding categories [12]. Sedentary professions, exemplified by office-based roles, often lead to extended durations of sitting, a habit linked to a myriad of adverse health repercussions, including elevated cancer risks [13,14]. It is noteworthy that office workers typically register <30 min of walking per day [15]. In contrast, roles demanding physical vigor, like construction, inherently involve more active routines, potentially fostering holistic health. Yet, the nexus between occupational physical activity, especially daily walking metrics, and the nuances of PTC is an area still awaiting comprehensive research. This retrospective analysis endeavors to bridge this knowledge chasm, juxtaposing daily walking steps across 2 disparate occupational groups – office and construction workers – to discern patterns related to PTC incidence and staging.

MATERIAL AND METHODS

Study design and participants

This study adopted a retrospective cohort design to explore the correlation between occupations – specifically office workers versus construction workers – and daily walking

steps. Furthermore, the authors aimed to assess how daily walking steps influence the risk of various PTC stages within these occupational categories. Participants were categorized into 2 main groups based on their job nature: office workers, representing sedentary professions, and construction workers, epitomizing physically demanding roles. The duration of the study hinged upon data accessibility and the desired timeframe for evaluating the association between daily walking steps and PTC risk.

Data collection

The authors gathered baseline demographic and clinical data such as age, sex, BMI, and specific thyroid-related parameters – thyroid peroxidase antibody (TPOAb), thyroglobulin antibody (TgAb), thyroglobulin (Tg), thyroid-stimulating hormone (TSH), free triiodothyronine (FT3) and free thyroxine (FT4) – from medical records and, where feasible, through linkage to administrative health databases. The information on the PTC stage at diagnosis was obtained from the medical records or cancer registry data. To assess daily walking steps, participants' self-reported data on physical activity and occupational tasks were collected, if available, through questionnaires administered at the time of PTC diagnosis or retrospectively through a follow-up survey.

Sample size calculation

Utilizing tools like G*Power, the sample size was determined. Given an effect size (Cohen's d) of 0.2, Power ($1-\beta$) of 0.90, and significance level (α) of 0.05, the computed requisite sample size was approx. 393 participants for each group, totaling 786 participants. Therefore, a rounded figure of 400 participants for each group was selected.

Inclusion and exclusion criteria

Inclusion criteria

Participants must have a confirmed PTC diagnosis (ranging from stage 0 to IV) as verified by pathology reports.

They should belong to either the office or construction worker occupational categories, possess exhaustive electronic health record data, and provide consent for study participation, acknowledging the confidentiality of their data and the study's non-impact on their medical care.

Exclusion criteria

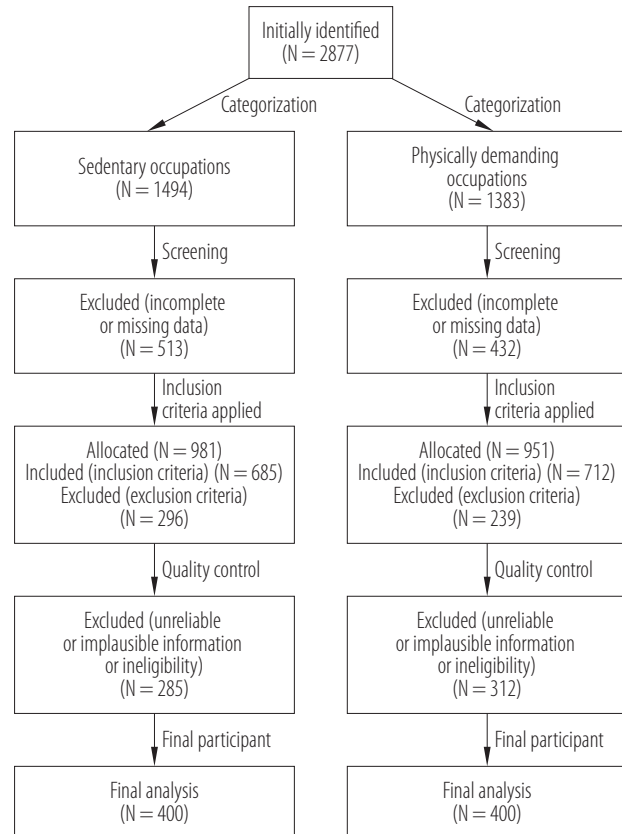
Exclusions encompass individuals with prior thyroid ailments or cancers, participants with severe comorbidities that might impede physical activity, those with incomplete health data, or conditions that could hinder daily walking, such as specific musculoskeletal or neurological disorders. Those not classified under the study's defined occupational categories and pregnant women, due to potential thyroid and activity-related variations during pregnancy, will also be excluded.

Participant recruitment and data screening for sedentary and physically demanding occupations

The study undertook a retrospective analysis of data from individuals engaged in either sedentary (office workers) or physically demanding (construction workers) roles. Initially, 2877 participants were earmarked. However, after a meticulous data validation phase, 400 participants from each category were finalized for the analysis (Figure 1). Initially, 1494 office workers and 1383 construction workers were identified. Comprehensive details on data screening for these occupations can be found in the supplementary file.

Outcome assessment

Papillary thyroid cancer volume was measured via ultrasound, computed tomography (CT), or magnetic resonance imaging (MRI). The volume was calculated by using the dimensions of the tumor ascertained from these images. The patients were asked to lie down on an examination table with the neck hyperextended. The sonographer then measures the thyroid lesion's dimensions – length, width, and depth – using the ultrasound machine's



The flowchart is a graphical representation of the systematic approach to participant recruitment and data screening, designed to ensure the credibility and representativeness of the data used in the study.

Figure 1. Flowchart of participant recruitment and data screening for office and construction workers, Shandong Provincial Third Hospital, Jinan, China, April 2021

built-in electronic calipers. If multiple nodules are present, each is measured individually. The volume of each thyroid lesion is calculated using the ellipsoid formula:

$$V = \pi/6 \times (D1 \times D2 \times D3), \quad (1)$$

where:

D1, D2, and D3 – the 3 diameters of the lesion [cm³].

The primary outcome is PTC risk, stratified by stage at diagnosis (stage 0, I, II, III, and IV). The secondary out-

comes include the risk of PTC overall, as well as the risk of PTC subtypes, if data on tumor histology and molecular characteristics are available:

- there is no evidence of a primary tumor (T0),
- the tumor is ≥ 2 cm in greatest dimension and is limited to the thyroid (T1),
- the tumor is >2 cm but <4 cm in greatest dimension and is limited to the thyroid (T2),
- the tumor is >4 cm in greatest dimension or any tumor with minimal extrathyroidal extension (T3),
- the tumor is any size and has extensive extrathyroidal extension (T4).

Laboratory assays include enzyme-linked immunosorbent assay (ELISA), radioimmunoassay (RIA), or chemiluminescence immunoassay (CLIA). The collected blood samples were sent to a laboratory for analysis. Free triiodothyronine, FT4, and TSH were commonly used to diagnose and manage thyroid diseases. Immunoassay techniques measure the levels of FT3, FT4, and TSH in the blood sample. An immunoassay determined the levels of these autoantibodies. The following techniques included ELISA or RIA. Thyroglobulin is a protein produced by the thyroid gland, and it can be a useful marker for thyroid cancer when measured in conjunction with other tests. Histological categorization of PTC was referred to supporting file.

Comparative study of the impact of daily walking steps on health parameters between construction and office workers

Step counts for each participant were primarily recorded using inbuilt step counters on their mobile phones based on the previous reported method [16]. To ensure reliability, the daily step counts were averaged over a minimum period of 1 month, during which there were no disruptions for the whole day in the step recorder. Participants confirmed that they consistently carried their phones with them during their occupational activities, thereby minimizing the likelihood of under-reporting. The data

were captured by short message/messaging service and a retrospective telephone interview.

Data management and quality control

Data management procedures were implemented to ensure the quality and completeness of the collected data. These procedures include the development of a detailed data management plan, establishment of data entry and coding guidelines, double data entry or validation checks, regular data cleaning and quality control, and secure storage of data in a password-protected database.

Ethical considerations

Federal Regulation 45 CFR 46.101(b) pertains to exemptions from certain requirements of the U.S. Department of Health and Human Services (HHS) regarding the protection of human subjects in research [17]. As per the Federal Regulations (45 CFR 46.101(b)), the authors believe this research project qualifies for a waiver because the research involves the study of existing data, documents, or records, which have been anonymized to protect the identities of the subjects. The study protocol was submitted to the relevant institutional review board or ethics committee for ethical approval waiver before initiating data collection (approval No. KYLL-2021100). All data will be anonymized to protect participants' confidentiality and privacy.

Statistical analysis

Descriptive statistics, including means, standard deviations, and proportions were calculated for all study variables. The Student's t-test is a statistical hypothesis test used to determine whether there is a significant difference between the means of 2 groups. A 1-way analysis of variance (ANOVA) was used to compare the mean daily walking steps among different occupations. Pearson's correlation analysis was used to study compare the variables in office and construction workers.

RESULTS

Baseline characters

A total of 800 participants were included in this retrospective cohort study, with 400 participants in each group: office workers (sedentary occupations), and construction workers (physically demanding occupations). The baseline characteristics of the study population were presented in Table 1. Age and BMI showed no statistically significant differences between the 2 groups ($p > 0.05$). The PTC volume was lower in construction workers when compared with that from office workers ($p = 0.0224$). Thyroid-related parameters FT3, TSH, TgAb, TPOAb, and Tg were significantly different between the 2 groups, with construction workers having generally lower values than office workers ($p < 0.05$). Construction workers took significantly more daily walking steps than office workers ($p < 0.0001$). The PTC stage is lower in construction workers ($p = 0.0013$). There is a significant difference in the normal histological type between the 2 groups, with more cases in the construction workers group ($p = 0.008$). No significant differences were observed in the other histological types ($p > 0.05$).

Daily walking steps

among construction and office workers

In this comparative analysis, the daily walking steps of 2 distinct occupational groups, construction workers and office workers, were assessed. The aim was to understand the variations in physical activity levels across these occupational roles, as evidenced by the metric of daily walking steps. Data for construction workers exhibited a daily walking step count of $M \pm SD$ 15 723 \pm 6563 steps. On the other hand, office workers demonstrated a daily step count of $M \pm SD$ 11 706 \pm 6237 steps. The results suggest more daily walking steps within the construction workers compared to the office workers (Table 1). This variation is statistically significant and indicates a greater level of physical activity in construction work compared to office work.

Further analysis was conducted to explore the variations in daily walking steps among different suboccupations within the broader categories of construction workers and office workers. Within the construction workers' category, the suboccupations studied included plumbers, laborers, masons, ironworkers, heavy equipment operators, carpenters, and electricians. The ANOVA analysis indicated no statistically significant difference in the daily walking steps among these suboccupations ($p > 0.05$) (Figure 2a). This suggests that the mean daily steps taken by individuals within these suboccupations are comparable. Similarly, within the office workers' category, suboccupations examined included software developers, administrative assistants, accountants, marketing professionals, managers, data entry clerks, and human resources professionals (Figure 2b). Consistent with the construction worker findings, no statistically significant difference in the daily walking steps was observed among these office suboccupations ($p > 0.05$). The lack of significant difference implies a level of uniformity in daily physical activity, as gauged by walking steps, across the suboccupations within each broad occupational group. This uniformity could be attributed to the similar nature of tasks and responsibilities, and hence, physical demands within these suboccupations.

Demographic, physical activity, and thyroid health parameters

between construction and office workers

The study showed no statistically significant differences in age and BMI between the construction and office worker groups ($p > 0.05$) (Table 1). Notably, the data exhibited a significant association between higher daily walking steps and lower PTC stages in the construction workers compared to the office workers ($p < 0.05$) (Table 1). This suggests that increased physical activity, as evidenced by greater daily walking steps among construction workers, may potentially contribute to a lower stage of PTC. This finding aligns with previous research suggesting physi-

Table 1. Comparative analysis of baseline characteristics and thyroid-related parameters in construction workers and office workers, Shandong Provincial Third Hospital, Jinan, China, April 2021

Variable	Participants (N = 800)		t	χ^2	p
	construction workers (N = 400)	office workers (N = 400)			
Females [n (%)]	247 (62)	266 (66)		1.962	0.161
Age [years] (M±SD)	43.88±14.22	43.82±14.56	0.067		0.940
BMI [kg/m ²] (M±SD)	24.93±5.098	25.54±5.699	-1.59		0.172
PTC volume [cm ³] (M±SD)	3.315±1.63	3.585±1.704	-2.288		0.052
Biochemical index (M±SD)					
FT3 [pg/ml]	4.297±0.521	4.69±0.619	-9.71		<0.0001
FT4 [ng/ml]	12.94±1.308	13.07±2.135	-1.015		0.310
TSH [μ iu/ml]	4.03±2.151	4.606±2.488	-3.505		0.0012
TgAb [iu/ml]	2.774±0.599	3.454±1.727	-7.438		<0.0001
TPOAb [iu/ml]	8.378±4.201	13.2±6.62	-12.31		<0.0001
Tg [ng/ml]	26.43±7.489	28.91±8.907	-4.268		<0.0001
daily walking steps [n]	15 530±10 686	11 757±6264	6.09		<0.0001
PTC stage [n (%)]				29.37	<0.0001
stage 0	32 (8)	14 (3.5)			
stage I	61 (15.25)	69 (17.25)			
stage II	165 (41.25)	152 (38)			
stage III	108 (27)	85 (21.25)			
stage IV	34 (8.5)	80 (20)			
Histological type [n (%)]					
normal	32 (8)	14 (3.5)		7.043	0.008
conventional type	134 (34)	124 (31)		0.3876	0.5336
follicular	58 (14)	59 (15)		0.008547	0.9263
oncocytic	21 (5.2)	20 (5)		0.02439	0.8759
papillary microcarcinoma	119 (30)	149 (37)		3.358	0.0668
sclerosing	7 (1.8)	6 (1.5)		0.07692	0.7815
solid	18 (4.5)	15 (3.8)		0.2727	0.6015
tall cell variant	11 (2.8)	13 (3.2)		0.1667	0.683
Multifocality [n (%)]					
absent	130 (32)	107 (27)		3.172	0.075
present	270 (68)	293 (73)			

FT3 – free triiodothyronine; FT4 – free thyroxine; TG – thyroglobulin; TGAB – thyroglobulin antibodies; TPOAB – thyroid peroxidase antibodies; TSH – thyroid stimulating hormone; PTC – papillary thyroid cancer.

The FT3 and FT4 are hormones produced by the thyroid gland. They are essential for many bodily functions, including growth, brain development, and metabolism. These measurements represent the portion of total hormones that are not bound to proteins in the blood, hence “free”. Thyroid stimulating hormone is a hormone secreted by the pituitary gland that stimulates the thyroid gland to produce FT3 and FT4. It is commonly measured to assess thyroid function. Thyroglobulin antibodies and TPOAB are autoantibodies that the body might produce against its own proteins (thyroglobulin and thyroid peroxidase, respectively) in certain conditions, such as autoimmune thyroid diseases. Thyroglobulin is a protein produced and used by the thyroid gland to produce the thyroid hormones T3 and T4. Its levels can be measured to monitor certain conditions related to the thyroid gland.

cal activity as a potential protective factor against certain cancers. Moreover, the study revealed lower levels of all biochemical indexes FT3, FT4, TSH, Tg, TgAb, and TPOAb in the construction workers compared to the office workers (Table 1, $p < 0.05$). This suggests that despite their higher physical activity levels, the construction workers displayed lower levels of thyroid function indicators, an aspect that warrants further exploration and interpretation considering the existing literature and potential confounding factors. Lastly, the PTC volumes in construction workers were slightly lower than those in office workers (Table 1, $p > 0.05$). This implies that while a trend towards lower PTC volumes in construction workers was observed, the evidence was not robust enough to assert a statistically significant difference.

Correlations between age, BMI, PTC volume, or thyroid function, and daily walking steps

In construction workers, several noteworthy correlations were observed. Age displayed a strong positive correlation with BMI, PTC volume, TSH, and Tg levels ($\rho > 0.5$) (Figure 3a), indicating that as age increases, these parameters also tend to increase. Conversely, age was found to have a negative correlation with daily walking steps ($\rho = -0.45$) (Figure 3a), suggesting that older individuals tend to have lower daily step counts. Body mass index displayed a strong positive correlation with PTC volume, TSH, and Tg levels ($\rho > 0.50$) (Figure 3a). These findings indicate that office workers with higher BMI tend to have larger PTC volumes, and higher TSH and Tg levels. The BMI was also found to have a weak negative relationship with daily walking steps ($\rho = -0.37$) (Figure 3a). PTC volume demonstrated a strong positive relationship with TSH, and Tg levels ($\rho > 0.55$) (Figure 3a), implying that larger PTC volumes are associated with more advanced disease and higher thyroid function measures. In contrast, PTC volume was negatively correlated with daily walking steps ($\rho = -0.51$) (Figure 3a), indicating

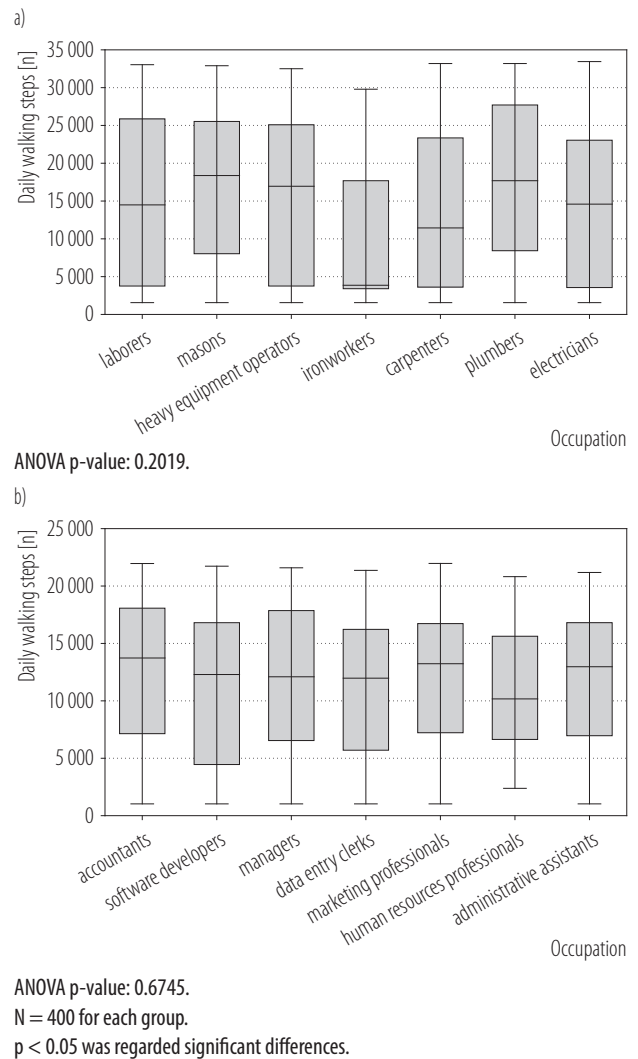
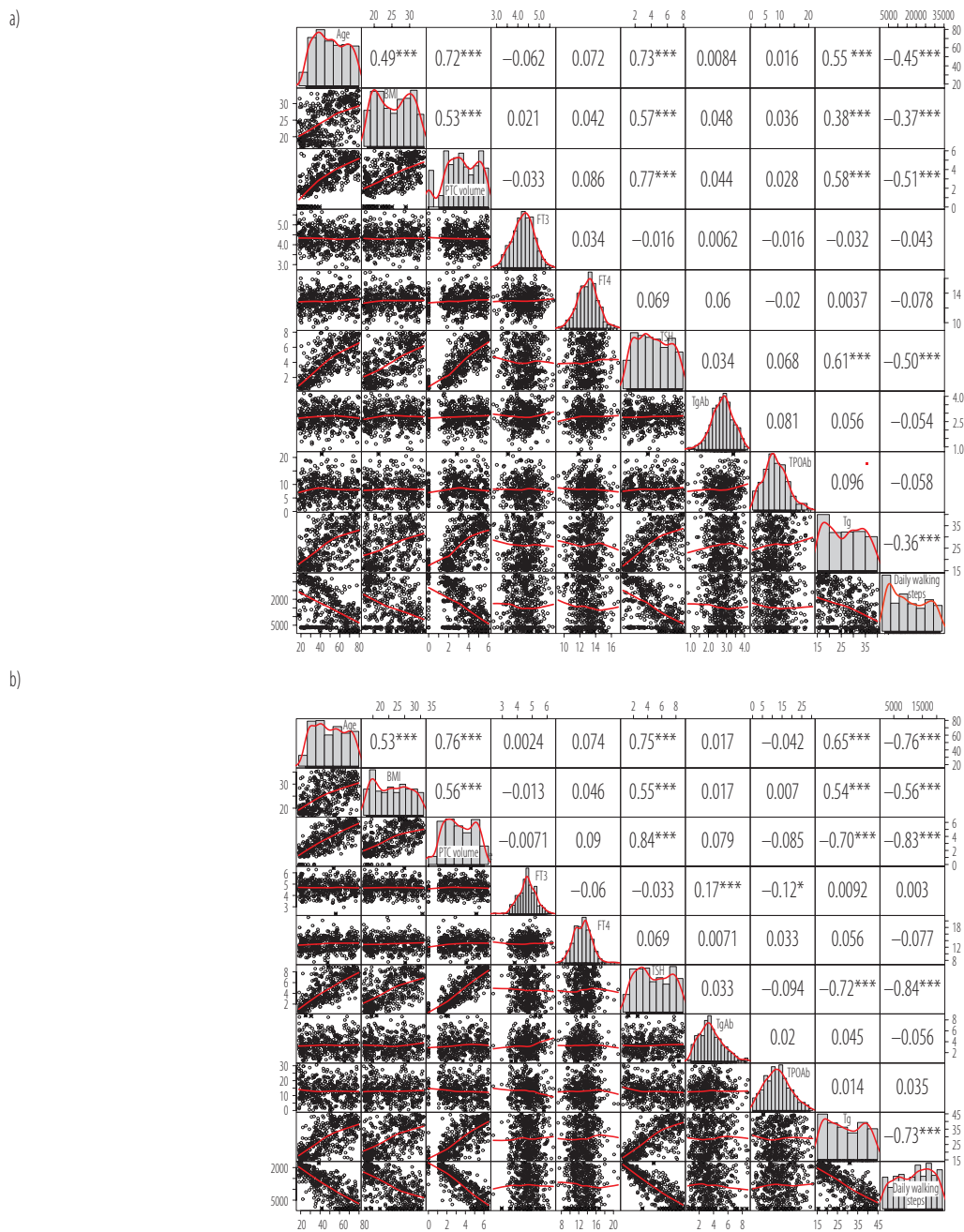


Figure 2. Variation in daily walking steps among suboccupations of a) construction and b) office workers, Shandong Provincial Third Hospital, Jinan, China, April 2021

that workers with higher step counts tend to have smaller PTC volumes. Levels of TSH showed a strong positive correlation with Tg levels ($\rho > 0.6$) (Figure 3a), suggesting that higher TSH levels are associated higher Tg levels. There was a negative correlation between TSH and daily walking steps ($\rho = -0.50$) (Figure 3a), indicating that as TSH levels increase, daily walking steps decrease. In office workers, the analysis revealed several correlations. Age showed a strong positive correlation with BMI, PTC volume, TSH, and Tg levels ($\rho > 0.5$) (Figure 3b). This suggests



The units are as follows: age – years, BMI – kg/m², PTC volume – cm³, FT3 – pg/ml, FT4 – ng/ml, TSH – μ iU/ml, TGAB – iU/ml, TPOAB – iU/ml, TG – ng/ml, daily walking steps – n. The figures present the correlation matrix illustrating the associations between age, body mass index (BMI), papillary thyroid carcinoma (PTC) volume, thyroid-stimulating hormone (TSH) levels, thyroglobulin (Tg) levels, and daily walking steps among office workers.

The Spearman's ρ values depicted signify the strength and direction of these correlations. A value closer to 1 indicates a strong positive correlation, while a value closer to -1 signifies a strong negative correlation.

* $p < 0.05$.

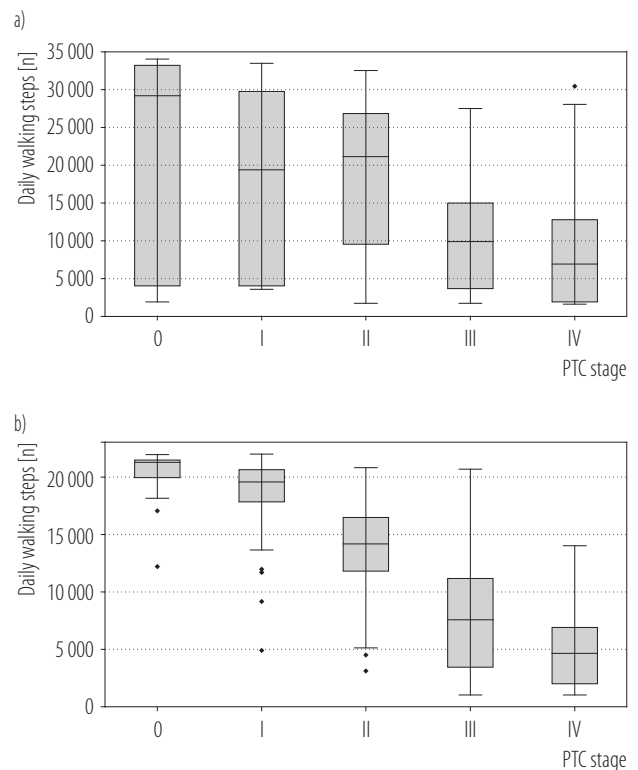
*** $p < 0.001$.

Figure 3. Correlation matrix of key demographic, clinical, and lifestyle parameters among a) construction and b) office workers, Shandong Provincial Third Hospital, Jinan, China, April 2021

that these variables tend to increase with age in this group. Additionally, there was a strong negative correlation between age and daily walking steps ($\rho = -0.76$) (Figure 3b), indicating that older office workers tended to walk less on average daily. The BMI displayed a strong positive correlation with PTC volume, TSH, and Tg levels ($\rho > 0.50$). These findings indicate that office workers with higher BMI tend to have larger PTC volumes, and higher TSH and Tg levels. The BMI was also found to have a strong negative relationship with daily walking steps ($\rho = -0.56$) (Figure 3b), suggesting that office workers with higher BMI tend to have lower daily walking step counts. The PTC volume had a strong positive correlation with TSH, and Tg levels ($\rho > 0.70$) (Figure 3b), suggesting that larger PTC volumes are associated with higher TSH and Tg levels. The PTC volume showed a strong negative correlation with daily walking steps ($\rho = -0.83$) (Figure 3b), suggesting that office workers with higher daily step counts tend to have smaller PTC volumes. The TSH had a strong negative correlation with daily walking steps ($\rho = -0.84$) (Figure 3b), indicating that as TSH levels increase, the daily walking steps decrease. The Tg levels also had a strong negative correlation with daily walking steps ($\rho = -0.73$) (Figure 3b), suggesting that as Tg levels increase, the daily walking steps decrease. These findings underscore the relationships between age, BMI, PTC volume, thyroid function, and daily walking steps among office workers. The negative correlation between daily walking steps and several key parameters, including PTC volume, TSH, and Tg levels, reinforces the potential protective role of physical activity against PTC progression. However, these are associative relationships and more research is needed to explore causality, underlying mechanisms, and potential confounding factors.

Daily walking steps had a negative relationship with PTC stages in construction and office workers

Among construction workers, there are noticeable differences in the step counts among the stages ($p < 0.001$) (Figure 4a). In the study involving construction workers,



$p = 0.0000$ for each group

The box plot showcases the median, quartiles, and outliers of the data.

PTC stages: 0 – no evidence of a primary tumor; 1 – the tumor is ≥ 2 cm in greatest dimension and is limited to the thyroid; 2 – the tumor is > 2 cm but < 4 cm in greatest dimension and is limited to the thyroid; 3 – the tumor is > 4 cm in greatest dimension or any tumor with minimal extrathyroidal extension; 4 – the tumor is any size and has extensive extrathyroidal extension.

ANOVA analysis indicates statistically significant differences in the step counts among the stages ($p < 0.001$).

Figure 4. Comparison of daily walking steps across different papillary thyroid cancer (PTC) stages in a) construction and b) office workers, Shandong Provincial Third Hospital, Jinan, China, April 2021

the number of participants across different PTC stages varied, with 32 in stage 0, 61 in stage I, 165 in stage II, 108 in stage III, and 34 in stage IV. Participants in the PTC stages exhibited distinct walking patterns. Those in stage 0 walked the most ($M \pm SD$ 21 036 \pm 13 591 steps). This was followed by stages I and II, where participants recorded 17 616 \pm 12 155 steps and 18 395 \pm 9759 steps, respectively. However, a notable decline was observed in stages III and IV. In stage III, participants averaged 10 404 \pm 7660 steps, while stage IV saw

an even lower average of 8978 ± 8144 steps. The data suggests a downward trend in walking activity from stage 0 through stage IV ($p < 0.001$), though there remains significant variability in step counts within each stage.

Among office workers, there are also noticeable differences in the step counts among the stages ($p < 0.001$) (Figure 4b). In the study involving office workers, the distribution of participants across the PTC stages was as follows: 14 in stage 0, 69 in stage I, 152 in stage II, 85 in stage III, and 80 in stage IV. The “Daily Walking Steps,” demonstrated varying patterns across the stages. Participants in stage 0 registered a mean of approx. $20\,083 \pm 2588$ steps, which was significantly greater than the other stages ($p < 0.001$). Similarly, individuals in stage I displayed a slightly lower but still elevated mean of around $18\,606 \pm 3016$ steps, showing a clear distinction from other stages ($p < 0.001$). For stage I, participants averaged about $13\,748 \pm 3830$ steps, which was moderately higher than the subsequent stages ($p < 0.001$). However, stages III and IV observed a substantial drop in the average steps, recording approx. 7881 ± 4778 and 4730 ± 3013 steps, respectively. Both these stages were markedly different from the preceding ones ($p < 0.001$). All these results suggest that daily walking steps have a negative relationship with PTC stages in construction and office workers.

DISCUSSION

This study provides an important contribution to the understanding of the protective role of occupational physical activity in the development and progression of PTC. The investigation unearthed a significant inverse association between daily step counts and PTC risk across both office workers and construction workers. This novel finding substantiates the premise that physical activity, as gauged by daily step count, plays a potentially protective role in PTC development and progression irrespective of occupational demands.

The protective effect of physical activity was especially pronounced among construction workers, those in physically demanding occupations. This observation may be

explained by the fact that physical activity is associated with various physiological changes, such as lower inflammation [18] and enhanced immune surveillance [19], that may reduce the risk of developing several types of cancer, including PTC [7]. More recent researches also support the benefits of physical activities to prevent thyroid cancer development. Fiore et al. [20] demonstrated that while general physical activity was not significantly correlated with thyroid cancer risk, walking every day for at least 60 min significantly reduced the risk. The prospective study from the Korea National Cancer Screening Cohort [21] found that participants with the highest levels of physical activity had a significantly reduced risk of developing thyroid cancer compared to those with the lowest activity levels. This association was particularly pronounced among certain subgroups, such as females with a higher body mass index, those with higher household incomes, and those who neither drank alcohol nor smoked [21]. The study revealed that while thyroid cancer incidence has been generally decreasing in the U.S., it continues to rise in 10 states, and significant state-level disparities exist based on race/ethnicity and age. Moreover, there is a strong correlation between increasing thyroid cancer trends and obesity prevalence, and a notable inverse correlation with physical activity levels, suggesting that lifestyle and environmental factors play a role in the incidence of thyroid cancer [22]. Moreover, construction workers maintaining a higher daily step count exhibited notably reduced levels of thyroid-related hormones and antibodies, such as TSH, FT3, FT4, TPOAb, TgAb, and Tg. These findings suggest that increased physical activity might be associated with improved thyroid function, potentially reducing PTC risk. In terms of thyroid hormones such as TSH, FT3, and FT4, 1 study found that physical activity, particularly aerobic exercise performed at the anaerobic threshold (70% of max heart rate), led to noticeable changes in hormone levels. While the levels of FT4, and TSH continued to increase when exercising at 90% of maximum heart

rate, the levels of FT3 started to fall [23]. Regarding the thyroid antibodies TPOAb, TgAb, and the thyroid hormone Tg, the available literature does not directly discuss the impact of physical activity. However, a study showed that high levels of these antibodies could influence how the thyroid responds to certain stimuli. In the case of this study, the stimulus was the pregnancy hormone hCG. Pregnant women with high levels of TPOAb or TgAb demonstrated a decreased thyroid response to hCG, which resulted in less of a decrease in TSH levels compared to women without high antibody levels [24]. Another study pointed out that abdominal obesity is a risk factor for TPOAb positivity in men, suggesting that abdominal obesity can enhance the risk of thyroid autoimmunity. While this does not directly address the effect of physical activity, it provides some insight into how certain lifestyle factors might influence thyroid antibody levels [25].

The negative correlation of daily walking steps with PTC stages and volumes signifies that individuals with a higher step count not only have a reduced PTC risk but also present with less advanced disease. The analysis further demonstrated a robust negative correlation between daily step count and other PTC risk factors such as BMI [14], providing additional evidence supporting the role of physical activity in PTC prevention. These findings align with previous studies linking higher physical activity levels with a lower risk of various types of cancers and other chronic diseases [10,26]. However, while these findings are promising, they should be interpreted with caution given the study's retrospective nature, which inherently cannot establish causality. Prospective cohort studies or randomized control trials are needed to confirm these findings. It is also important to note that, while this study investigated the role of occupational physical activity, PTC development and progression are likely to be influenced by a range of genetic, environmental, and lifestyle factors. Therefore, comprehensive approaches incorporating multiple prevention strategies are crucial to effectively reduce PTC risk.

Physical activity, specifically measured through daily walking steps, also plays a pivotal role in the well-being and recovery of breast cancer survivors. Leveraging mobile technology provides a novel avenue to monitor and potentially enhance walking steps, thereby offering tangible benefits in reducing mental distress and promoting healthier outcomes among breast cancer patients [27]. Walking steps have garnered interest in oncology research as a potential modifiable factor impacting the well-being and health outcomes of patients, including those with breast cancer. Emerging evidence from this study suggests that achieving a threshold of >10 000 steps daily offers tangible health benefits, reinforcing the notion that regular walking can serve as a feasible and safe therapeutic intervention for adolescents, irrespective of their cancer status [28]. Physical activity, especially walking, has been identified as a critical component of prehabilitation in patients diagnosed with kidney cancer, with specific emphasis on assessing and enhancing their functional mobility. Utilizing tools such as the 15-foot walking speed test and implementing structured exercise plans, patients are initially evaluated based on their baseline activity and subsequently encouraged to achieve a target of 10 000 daily steps, underscoring the significance of ambulatory activity in their therapeutic regimen [29]. Consequently, consistent walking and achieving targeted step counts not only play a pivotal role in PTC prehabilitation but also have the potential to influence and mitigate the development of various other cancers.

Functional tests such as low threshold Performance Matrix Tests could play a pivotal role in identifying musculoskeletal system weak links. These tests could provide essential information on the athletes' physical condition, allowing for the development of tailored training programs aimed at improving motor control and reducing the risk of injuries caused by motor system dysfunctions [30]. Evaluating the preventive role of walking in PTC risk necessitates a multifaceted approach to health assessment. Chronic inflamma-

tion, a known precursor to various cancers, can be gauged through blood tests like C-reactive protein (CRP) and interleukin 6 (IL-6), with walking believed to modulate such inflammatory markers associated with PTC risk [31–33]. Similarly, assessing hormonal levels, including thyroid hormones (T3 and TSH), and other metabolic indicators ROS can pinpoint imbalances often linked to diseases like PTC and can be affected via walking [34,35]. Regular walking aids in both hormonal regulation and metabolic function, reinforcing its potential protective stance. On the weight management front, metrics like BMI, body fat percentage, and waist-to-hip ratios provide insights into weight-related health risks. With overweight and obesity being prominent risk factors for PTC [35], a structured walking regimen can be pivotal in maintaining weight within healthy parameters [36]. Taken together, these diagnostic measures not only underscore the multifaceted benefits of walking but also emphasize its importance in a preventive healthcare strategy, especially concerning PTC risk. Unfortunately, the current retrospective study does not feature these tests, they represent a promising avenue for comprehensive future research into PTC risk factors and overall health.

CONCLUSIONS

This retrospective analysis presents compelling evidence of the inverse relationship between occupational daily walking steps and the risk and progression of PTC. The study, which encompassed 800 individuals with varying stages of PTC, discerned that higher frequencies of daily walking steps were significantly associated with a reduced risk of PTC onset and lower stages at diagnosis. This protective effect was particularly notable among construction workers, who typically recorded more daily steps compared to office workers. The study also found that higher daily walking steps correlated with lower levels of thyroid-related biochemical markers and were inversely associated with BMI, age, PTC volumes, and levels of TSH and Tg. These findings suggest that increasing daily physical activ-

ity, particularly walking, could be a beneficial strategy in mitigating the risk and slowing the progression of papillary thyroid cancer. This study adds valuable insights into the impact of physical activity on thyroid cancer, an area previously not extensively explored.

Data availability statement

The original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding authors.

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