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A Dose-Response Relationship between Types of Physical Activity and Distress

This study aimed to examine whether a dose-response relationship exists between psychological distress and types of physical activity (total, occupational, and leisure-time). The study subjects (233 men and 313 women) were recruited for a study on cardiovascular disease in the Yangpyeong community located in South Korea. The type and characteristics of physical activity were measured with a modified version of the Stanford 5 city project's questionnaire by well-trained interviewers using a standard protocol. The Psychological Well-being Index-Short Form was used to assess psychological distress. Both the intensity and duration of time in either total physical activity or occupational physical activity (OPA) were not related to the distress score. However, a long duration of time (1 hr/day) in severely intensive (≥6 metabolic equivalent) OPA was related to a high distress score in men (14.1 for none vs. 19.7, *p-for-trend*=0.005), even after the adjustment for leisure-time physical activity (LTPA). A long duration in time (1 hr/day) in LTPA was related to a lower distress score in men independent of their OPA (16.7 for none vs. 13.1, *p-for-trend*=0.02). In conclusion, the dose-response relationship of physical activity on psychological distress appeared to differ among the different types of activities. The type of activity may be an important determinant of whether physical activity produces psychological benefits.

Key Words : *Motor Activity; Distress; Dose-Response Relationship*

Kirang Kim, Young Jeon Shin, Joung Hyun Nam*, Bo Youl Choi, and Mi Kyung Kim

Departments of Preventive Medicine, and Psychiatry*, College of Medicine, Hanyang University, Seoul, Korea

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Address for correspondence
Mi Kyung Kim, M.D.
Department of Preventive Medicine, Hanyang University, College of Medicine, 17 Haengdang-dong, Seongdong-gu, Seoul 133-791, Korea
Tel : +82.2-2220-0667, Fax : +82.2-2293-0660
E-mail : kmkkim@hanyang.ac.kr

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INTRODUCTION

Physical activity can vary with regard to type, purpose (e.g., leisure, occupation, and rest), intensity, duration, frequency, and volume (1), and thus a comprehensive assessment of physical activity with detailed measurements is needed to make public health recommendations. For most studies, the benefits of physical activity on psychological distress have been limited to a specific type of physical activity using gross estimates of measurements (2, 3). Numerous studies have found that leisure-time physical activity (LTPA) has relieved psychological distress (i.e., depressive symptoms) regardless of culture and age (3-12), and furthermore had a possible protective effect against the development of depression in many observational studies (2, 3, 8, 13-15). However, there is still a lack of evidence to support the existence of a dose-response relationship between LTPA and psychological distress (2, 3). Kesamiemi et al. (16) reviewed observational studies that focused on the dose-response effect of physical activity on health and found the evidence for a dose-response relationship between physical activity and all-cause mortality and chronic diseases but little evidence of a dose-response relationship with psychological distress such as anxiety and depression. The reason was that studies on the relationship between physical activity and distress examined the level of physical activity with gross estimates of the LTPA status such as the classification of activity type based on intensity (low/moderate/high), frequency (low/moderate/high based on frequency score), or a subjectively perceived activity level (no/occasional/regular or little/moderate/much) (2). Thus, the information without a quantified amount of physical activity based on detailed measures of intensity and duration could not demonstrate a dose-response gradient between the amounts of physical activity and reduction in distress. Given that a quantified amount of physical activity can allow direct translation to public health recommendations, assessing the dose-response relationship between psychological distress and physical activity is important.

Many studies have reported the relationship between LTPA and distress, but the relationship between distress and occupation physical activity (OPA) or total physical activity (TPA) has not yet been studied. Job stress has been known to increase psychological distress (17, 18), and thus the effect of OPA on distress might be different from that of LTPA.

Therefore, the purpose of this study was to determine whether a dose-response relationship exists between psychological distress and each of the three types of physical activity (TPA,

OPA, and LTPA) measured in both intensity and duration, and also how the different types of activities are related to each other in affecting distress in a general population.

MATERIALS AND METHODS

Study subjects

Study subjects who were at least 20 yr old were recruited for a study on cardiovascular disease risk factors starting in November of 2002 to January to 2005 from Yangpyeong, a city located in the Gyeonggi province of Korea. Only the subjects who were between the ages of 20 and 64 yr old and who had also completed the available questionnaire on psychological distress and physical activity were recruited for this study. Of the 563 subjects who met these requirements, subjects were excluded from the study if they had severe chronic diseases at the time of recruitment or a history of diseases, such as cancer (n=10), myocardial infarction (n=1) or stroke (n=6). Thus, a total of 546 study subjects were used for the analysis (233 men and 313 women). The participants signed the approved informed consent form provided by the Hanyang University Medical Center Institutional Review Board.

Measurements

General characteristics and anthropometrics

An interviewer-administered questionnaire was used to collect data on age, sex, job status (manual, non-manual, or others), education level (less than middle school, or more than high school), the disease history of hypertension, diabetes, or self-reported dyslipidemia (yes/no), the family disease history of hypertension, diabetes, angina, stroke, or myocardial infarction (yes/no), smoking status (current smoker, ex-smoker, or non-smoker), and drinking status (current drinker, ex-drinker, or non-drinker). Body Mass Index (BMI) was calculated by dividing the weight (kg) by the height squared (m^2). Height was measured with a standard height scale to the nearest 0.1 cm, and weight was measured with a metric weight scale to the nearest 0.1 kg.

Psychological distress

The Psychological Well-being Index-Short Form (PWI-SF) was used for the assessment of psychological distress, which is a modification of the Goldberg's General Health Questionnaire (GHQ). The GHQ is used as a validated screening questionnaire for non-psychotic psychological distress and is suitable for use in general population studies (19). The PWI is a 45-item self-rating instrument, which was developed for adult workers and was validated with the GHQ-60 (20). The PWI-SF is the short form of the PWI. The Cronbach's alpha was 0.9, and the correlation between PWI-SF and PWI was 0.95 (20). The PWI-SF score ranges from 0 to 54 when a 4-item scale is used. A high score designates a higher level of psychological distress, with a score of 27 or greater indicating a high risk of having psychological distress. The Cronbach's alpha for the PWI-SF used in this study was 0.87, which indicated a relatively high level of reliability.

Physical activity

Physical activity was measured with an interviewer-administered questionnaire by well-trained interviewers who were trained at least twice with a standard protocol and were examined with a pilot-test. The questionnaire was modified from a physical activity questionnaire that was used for the Stanford 5 city project, which was administered by an interviewer and was based on a seven-day total activity recall, which included work, household, and leisure activities (21). There were four types of physical activities that were included in this study, including sleeping (1.0 metabolic equivalent [MET]), five different sedentary activities (1.0-1.4 MET), non-sedentary activities (OPA and LTPA), and only LTPA. Specifically for the non-sedentary activities and the LTPA, activities were classified into three categories (moderate, hard, or severe) according to the intensity of the activity which was expressed in terms of metabolic equivalents (METs) (1). Activity classifications by METs were as follows: moderate activity (3 MET for non-sedentary activities and 4 MET for LTPA), hard activity (5 MET for non-sedentary activities and 6 MET for LTPA), and severe activity ($\geq$6 MET for non-sedentary activities and $\geq$7 MET for LTPA). All activities were measured by the average amount of hours spent per week performing each activity in the past year.

Table 1 shows the compendium of physical activities examined in this study. In order to assess the amount (level) of physical activity, the MET-hours scores were used (22). The amount of TPA (MET-hours score) was calculated by multiplying the average MET of TPA by the hours spent in TPA. The MET-hours scores for LTPA were calculated by multiplying the MET value of each specific activity (moderate, hard, and severe) by the total hours spent per week on the activity and then summing all of activities together (22). The MET-hours score for OPA was estimated by multiplying the MET value of the non-sedentary activities by the differential value between the hours spent per day in non-sedentary activity and hours in LTPA, because the hours spent in non-sedentary activity is the sum of the hours spent in LTPA and OPA. Exercise status was categorized into two groups; <22.5 MET-hours/week for non-LTPA, $\geq$22.5 MET-hours/week for LTPA, where 22.5 MET-hours/week represents the minimum recommended level based on the MET value for brisk walking (4.5 MET) (23).

Statistical analysis

Separate analyses were conducted for men and women due to their different general characteristics. Both the distribution of the type of physical activity by the general characteristics and the mean value of the total PWI-SF score by each subgroup

Table 1. Compendium of physical activities

Elements of activity	Type	Abbreviation	Unit	Operational definition
Amount of physical activity (metabolic equivalent [MET]-hours scores)	Total physical activity	TPA	MET-hours	$\sum$ MET-hours of all PA_i where $PA_i = \sum$ Intensity of $PA_i \times$ hours spent in PA_i, PA_i denotes sleeping, five sedentary activities, and three non-sedentary activities
	Leisure-time physical activity	LTPA	MET-hours/week	$\sum$ (MET of $LTPA_j \times$ hours spent in $LTPA_j$ per week) where j=1, 2, 3 denotes moderate, hard, severe LTPA
	Occupational physical activity	OPA	MET-hours/day	$\sum$ {MET of $OPA_j \times$ hours spent in OPA_j per day) *where* j=1, 2, 3 denotes moderate, hard, severe OPA, OPA_i denotes the difference of non-sedentary activity$_i$ and $LTPA_i$
Intensity of physical activity	Intensity for leisure-time physical activity	Intensity for LTPA	MET/hour/day	Average intensity of moderate, hard, severe LTPA per hour
	Intensity for occupational physical activity	Intensity for OPA	MET/hour/day	Average intensity of moderate, hard, severe OPA per hour
Time spent in physical activity	Time spent in leisure-time physical activity	Duration of time in LTPA	Hour/day	Average hours spent in moderate, hard, severe LTPA per day
	Time spent in occupational physical activity	Duration of time in OPA	Hour/day	Average hours spent in moderate, hard, severe OPA per day
	Time spent in severely intensive occupational physical activity	Duration of time in severe OPA	Hour/day	Hours spent in only severe OPA per day

according to each type of physical activity were examined. The group differences were analyzed by using the chi-square test and the Turkey's least-squares analysis of means using a general linear model. The dose-response relationships were tested using the trends for the mean values of the total PWI-SF score by the different characteristics of each physical activity type. For the trend test, the categorized variables (i.e., subgroup variables) for the types and characteristics of each physical activity were treated as continuous variables assigned with the median value within the category. All analyses were conducted using SAS software (version 8.0, SAS Institute Inc., Cary, NC, U.S.A.).

RESULTS

General characteristics according to sex are shown in Table 2. Men made up 42.7% of the study population, and the mean age was 50.4 yr for men and 49.2 yr for women. Most of the subjects had a manual job (88.8% for men and 71% for women), and these jobs included farmer, craftsman, laborer, or employee of a store. Men had a higher level of education than did women. Approximately half of the men were current smokers, whereas only a few of the women were current smokers (1.86%). Approximately 70% of the men and 40% of the women were current alcohol drinkers. The average BMI was 25 kg/m^2 for both men and women. The total PWI-SF score was significantly higher in women than in men (16.0 for men and 20.1 for women).

Table 3 shows the distribution of the subjects by their types of physical activity. Men reported significantly higher levels of all types of physical activities than did women (14.2 MET-hours/day for OPA in men and 10.9 MET-hours/day in women; 13.6 MET-hours/week for LTPA in men and 8.05 MET-hours/week in women). Within each type of physical activity, the intensity and duration of time in OPA and the duration of time in LTPA were significantly different by sex. The proportion of subjects with an LTPA score of at least 22.5 MET-hours/week was 18.8% (n=44) for men and 10.9% (n=35) for women.

Table 2. General characteristics of study subjects

Characteristics	Men	Women	*p* value
No (%)	233 (42.7)	313 (57.3)	
Age, mean (SE)	50.4 (0.69)	49.2 (0.60)	0.205
Job, Manual (%)	88.8	71.0	<0.001
Education, ≥High school (%)	45.0	31.8	<0.001
Medical history (%)	30.7	35.3	0.46
Hypertension	10.3	12.5	0.39
Diabetes	7.76	6.13	0.46
Hyperlipidemia	0.74	0.13	0.53
Family disease history* (%)	47.0	45.0	0.66
Ex-smoker	27.2	0.31	<0.001
Current smoker	47.0	1.86	<0.001
Alcohol drink (%)			
Ex-drinker	10.3	1.86	<0.001
Current drinker	68.8	39.9	<0.001
BMI, mean (SE)	24.6 (0.21)	25.0 (0.19)	0.16
Total PWI-SF score, mean (SE)	16.0 (0.62)	20.1 (0.53)	<0.001

All values are age-adjusted.
*Family disease history is the proportion of subjects with a family history of hypertension, diabetes, angina, stroke, or myocardial infarction (yes/no).
SE, standard error; BMI, body mass index; PWI-SF, psychological well-being index-short form.

The potential confounding factors for the relationship be-

Table 3. The distribution of subjects by the type of physical activity

Characteristics	Men (n=233)	Women (n=313)	*p* value
TPA (average MET-hour), mean (SE)	43.8 (0.64)	39.1 (0.56)	<0.001
Quintile 1	30.8*	29.4	
Quintile 3	42.9	37.1	
Quintile 5	57.3	50.9	
OPA (MET-hour/day), mean (SE)	14.2 (0.67)	10.9 (0.57)	<0.001
Intensity for OPA (MET/hour/day), mean (SE)	4.53 (0.03)	4.33 (0.02)	<0.001
Quintile 1	4.03*	4.03	
Quintile 3	4.48	4.22	0.001
Quintile 5	5.00	4.87	
Duration of time in OPA (hour/day), mean (SE)	3.34 (0.14)	2.75 (0.12)	0.002
≤1	21.0†	27.2	0.003
≤3	25.3	33.2	
3-5	33.7	26.7	
> 5	12.0	13.0	
Duration of time in severe OPA (hour/day), mean (SE)	0.45 (0.06)	0.21 (0.05)	0.002
0	62.6†	79.7	<0.001
0-1	25.1	14.3	
>1	12.3	6.0	
LTPA (MET-hour/week), mean (SE)	13.6 (1.33)	8.05 (1.15)	0.002
Exercise status‡, %	44 (18.8)	35 (10.9)	0.01
Intensity for LTPA (MET/hour/day), mean (SE)	2.28 (0.17)	1.88 (0.15)	0.07
0	56.3†	61.2	0.03
0-4	18.3	23.4	
> 4	25.4	15.4	
Duration of time in LTPA (hour/day), mean (SE)	0.37 (0.30)	0.24 (0.03)	0.006
0	56.3†	61.2	0.04
< 0.5	20.9	22.2	
0.5-1	9.6	10.2	
>1	13.2	6.4	

All values are age-adjusted.
*, Median value; †, percentage; ‡, proportion of subjects with an LTPA score ≥22.5 MET-hours/week.
TPA, total physical activity; SE, standard error; OPA, occupational physical activity; LTPA, leisure time physical activity; MET, metabolic equivalent.

tween total PWI-SF and physical activities were examined. In general, a manual job and lower education level were related to an increase of the TPA, intensity for OPA, and time for total OPA, and to a decrease of LTPA. Family disease history had a negative relationship with duration of time in severely intensive OPA in men (*p for trend* <0.001) and a positive relationship with the duration of time in LTPA in women (*p for trend*=0.04). BMI was positively related to the exercise status and duration of time in LTPA in women (*p for trend*=0.02). There was a negative relationship between OPA and LTPA.

Three models were used to estimate the mean of the total PWI-SF score for the TPA, OPA, and LTPA (Table 4). The first model adjusted only for age as a covariate, while the second model adjusted for both age and socio-demographic variables, which were both significant according to bivariate analysis. The third model for TPA and OPA included the exercise status variable that accounted for both the intensity and the duration of time in LTPA. In the third model for LTPA, the duration of time in total OPA, which had a relatively stronger relationship with LTPA among characteristics of OPA, were added. TPA and OPA were not related to the mean of the total PWI-SF score. However, a longer duration of time spent in severely intensive OPA was significantly related to a higher total PWI-SF score in men (14.1 for none vs. 19.7 for >1 hr/day, *p for trend*=0.005), which was independent of other potential confounding variables and LTPA status. The LTPA was negatively related to the total PWI-SF score in men. The greater intensity and longer duration of time spent in LTPA were related to lower total PWI-SF scores in men (*p for trend*= 0.05 for intensity, *p for trend*=0.01 for time) after adjusting for age and socio-demographic variables. After adjusting additionally for duration of time in total OPA, a significant relationship was shown in only the duration of time in LTPA (16.7 for none vs. 13.1 for >1 hr/day, *p for trend*=0.02).

The subjects were stratified into either the non-LTPA or the LTPA groups, and the effect of the duration of time in severely intensive OPA and LTPA on the mean of PWI-SF score in men (Fig. 1) was analyzed in order to evaluate whether the effect of LTPA on the PWI-SF score is different between the levels of the time spent in severely intensive OPA. The distress score in the LTPA group was lower than in the non-LTPA group, regardless of the duration of time in severely intensive

Table 4. Mean of the total PWI-SF score by total physical activity, occupational physical activity, and leisure-time physical activity

	TPA (average MET-hour)				Intensity for OPA (MET/hour/day)				Duration of time in OPA (hour/day)					Duration of time in severe OPA (hour/day)*			
	Q1	Q3	Q5	*p*-trend	Q1	Q3	Q5	*p*-trend	≤1	≤3	3-5	>5	*p*-trend	0	0-1	>1	*p*-trend
Men																	
Model 1	17.2 (1.36)	18.1 (1.35)	15.2 (1.35)	0.67	16.8 (1.44)	17.9 (1.42)	17.8 (1.43)	0.99	16.7 (1.31)	13.7 (1.17)	16.4 (1.04)	18.0 (1.33)	0.19	16.4 (0.79)	14.3 (1.25)	20.9 (1.81)	0.02
Model 2	–	–	–	–	–	–	–	–	16.9 (1.33)	13.8 (1.17)	15.6 (1.05)	17.2 (1.33)	0.56	16.4 (0.80)	14.3 (1.26)	21.1 (1.85)	0.02
Model 3	–	–	–	–	14.4 (1.64)	15.6 (1.60)	16.5 (1.48)	0.68	15.8 (1.42)	13.2 (1.20)	14.7 (1.15)	15.9 (1.47)	0.69	14.1 (1.05)	12.7 (1.33)	19.7 (1.86)	0.005
Women																	
Model 1	19.8 (1.24)	19.1 (1.24)	20.9 (1.24)	0.74	18.2 (1.78)	21.9 (1.25)	21.4 (1.25)	0.69	20.8 (1.04)	18.9 (0.94)	20.3 (1.06)	20.8 (1.50)	0.76	20.1 (0.62)	20.5 (1.49)	19.3 (2.27)	0.72
Model 2	18.9 (1.71)	18.5 (1.59)	20.1 (1.80)	0.73	17.8 (2.20)	22.0 (1.79)	21.4 (1.86)	0.26	19.7 (1.55)	17.9 (1.47)	19.2 (1.53)	19.9 (1.97)	0.73	–	–	–	–
Model 3	–	–	–	–	17.7 (2.29)	21.9 (1.94)	21.3 (2.01)	0.23	19.5 (1.73)	17.7 (1.61)	19.0 (1.69)	19.6 (2.13)	0.74	20.0 (1.05)	20.4 (1.59)	19.1 (2.37)	0.72

*, Severe OPA includes OPA activities with ≥6 metabolic equivalent (MET) intensity.
Model 1: age-adjusted. Model 2: age+socio-demographic variables based on a bivariate analysis (TPA: no variable in men and job in women; intensity for OPA: no variable in men and job in women; duration of time in OPA: education in men and job in women; duration of time in severe OPA: family history in men and no variable in women). Model 3: age+demographic variables+exercise status (Yes/No based on 22.5 MET-hours/week).
TPA, total physical activity; OPA, occupational physical activity; LTPA, leisure time physical activity; MET, metabolic equivalent.

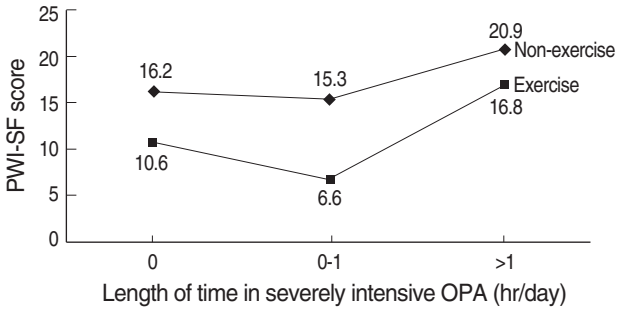

Fig. 1. The effect of LTPA and duration of time in severe OPA on the total PWI-SF score. Adjusted for age, job, disease history, family history of disease, and BMI.
Non-exercise: LTPA score <22.5 metabolic equivalent-hour/week, Exercise: LTPA score ≥22.5 metabolic equivalent-hour/week.

OPA. The LTPA was likely to decrease the total PWI-SF score even in the group with severely intensive OPA (within the group with severely intensive OPA, the total PWI-SF score for the LTPA group=16.8, while the total PWI-SF score for the non-LTPA group=20.9).

DISCUSSION

This study found that intensity and duration of time in TPA and total OPA had no relationship with psychological distress in either men or women. However, the duration of time spent in severely intensive OPA was related to a high level of distress independent of the LTPA in men. A long duration of time in LTPA was related to a low level of distress independently of the OPA in men. The increased distress by the duration of time in severely intensive OPA was higher in the non-LTPA group than in the LTPA group, regardless of the duration of time spent in severely intensive OPA. None of the studies, to our knowledge, examined the dose-response relationship between distress and physical activity according to the types of physical activity, such as the TPA, OPA, and LTPA.

Few studies have tried to analyze the dose-response relationship between distress and a specific type of activity, i.e., LTPA (8, 13, 14). A cross-sectional study of the household populations in both the United States and Canada found that the level of recreational activity (kcal/kg/day) was associated with a positive mood, general well-being, and symptoms of anxiety and depression (8). A prospective study observed an inverse linear relationship between depression and sports (hr/week) and recreational physical activities (kcal/week) (14). Both studies examined the energy expenditure, which accounts for both the intensity and duration of the physical activity, in order to assess the dose-response relationship but the information obtained was not enough to make a public health recommendation. Bhui and Fletcher found that the dose-response relationship between distress and LTPA was inconsistent between the intensity and the duration of the activity with a nested case-control study (13). The dose-response relationship of distress was related to the duration of LTPA but not to the intensity, suggesting that a low-intensity exercise for long periods of time appear to have a beneficial effect on distress. This result is different from the results of our study, which shows that a dose-response effect exists for both intensity and duration on distress after an adjust-

ment is made for general confounding variables. The reason for the inconsistent results regarding the intensity may be explained by the different methods of measuring the intensity between the two studies. Our study assessed the intensity using a categorical variable based on the average level of METs accounted for by time, whereas Bhui and Fletcher used a variable classified by the kinds of exercise performed, where low-intensity activities include walking or gardening, and high-intensity activities include basketball, tennis, swimming, or boxing. Using this alternate method may result in obscuring the effect of intensity by the residual variation of intensity within an intensity category.

In general, the beneficial effects of a higher dose of physical activity on health is widely accepted, but these relationships are not always linear (24). A study found that excessive physical activity (daily physical activity or an extended duration of activity ($\geq$90 min/day)) dose not improve a person's Health-Related Quality of Life (HRQOL), but rather reduces it (24). This finding implicates that excessive physical activity may have a detrimental effect on health. This study supported this possibility, showing that severely intensive OPA may be related to distress because the total OPA was not related to distress but rather an extended period in severely intensive OPA increased distress. Several studies have reported the effects of OPA on the risk of chronic diseases, such as strokes (25), cardiovascular disease (26), and diabetes (27). They showed that OPA slightly decreased the risk of the diseases and the beneficial effects were greater when it was combined with LTPA (25-27). A possible explanation for the different results from our study may be due to the different methods of measuring OPA or to the different effects of OPA on different outcomes. Whereas our study measured the volume of OPA, which accounted for both intensity and duration, the previous results of OPA were based on the level of OPA classified by job type related to the intensity of work, which may imprecisely assess the extent of severely intensive OPA.

Several studies have been able to demonstrate a positive effect of activity regardless of the type of chronic disease, but different effects caused by the type of activity might be shown in psychological distress. Stephens's study on the relationship between physical activity and positive affect scores in women for the Canada Health Survey observed that women who combined recreation with household chores (kcal/kg/day) had a lower positive affect score than those who partook of only recreational activities. This supports our finding that the type of physical activity may be an important element in obtaining psychological benefits from it. We examined how the duration of time in severely intensive OPA is related to LTPA on distress because of the possibility that severely intensive OPA may have a harmful effect on distress. The results indicate that the LTPA is likely to decrease the distress score, regardless of the duration of time in severely intensive OPA. This suggests that LTPA might even be recommended for people who engage in work that requires severely physically intensive types of activities in order to relieve psychological distress.

The effect of psychological distress measured with PWI-SF on health-related outcomes has been shown in several previous studies. A study on the association between PWI-SF and lipid profiles (28) found that the level of total cholesterol was likely to be higher in a group with moderate PWI-SF scores (13 to 25) than a group with mild PWI-SF scores (<13). Other studies have reported that the PWI score was related to low systolic blood pressure (29) and irritable bowel syndrome (30).

In the present study, a higher level of psychological distress was observed in women than in men, as has been previously reported (5, 31, 32). However, significant effects of OPA and LTPA on distress were shown only in men. Unlike the findings from this study, the positive effect of LTPA on psychological distress was shown regardless of the sex of Korean employees living in urban areas (4, 5) and in the several community-based studies conducted in the United States (7, 9, 33, 34). The effect of OPA on chronic disease was also consistent between the sexes (25, 35). One study found gender differences in the protective effect of physical activity in that the protective effect occurred only in men (13). Their reasoning for this is because the women in the study were likely to be more vulnerable to morbidity and engaged in less healthy lifestyles, and thus the protective effect afforded by exercise might be less amenable. Similarly, in this study, a possible explanation for why women have no protective effect from physical activity may be due to their low range of exposure (especially in LTPA) or their unique characteristics (not enough variation of physical activity) related to living in a rural environment.

The results of this study are subject to some limitations. Firstly, due to the cross-sectional nature of this study, it is still not clear whether physical activity reduces psychological distress or whether a reduction in psychological distress leads to physical inactivity. However, the study subjects visited our community health center during the recruitment period, and thus it is less likely that the level of their psychological distress at that time was making them physically inactive. Secondly, the study subjects did not score high on either distress or LTPA, so the results may underestimate the dose-response relationship. In addition, the possible adverse effects of too much of a high-level of LTPA, that is, "exercise abuse", could not be carefully analyzed (24). Lastly, the self-reported measurements of physical activity may be an imprecise method for estimating the type and duration of physical activity. However, the level of LTPA was comparable to the results from the Korea National Health and Nutrition Survey (36). Despite these limitations, this study is able to demonstrate that the guidelines for LTPA that are recommended by the World Health Organization and the Centers for Disease Control and Prevention (23, 37) may be applied to psychological well-being as well as to decreasing people's risk for diseases. Most of the previous studies could not evaluate the practical guidelines made about LTPA for general populations regarding psychological distress because they did not have detailed

data on the amount of physical activity.

In conclusion, the type of activity may help determine the extent of psychological benefit that can be derived from physical activity. Both the TPA and the OPA were not related to distress but a high volume of OPA, i.e., duration of time in severely intensive OPA had a positive dose-responsive relationship with distress in men. All characteristics relating to LTPA, including LTPA status, intensity, and duration of time, had a negative dose-responsive relationship with distress in men. The effect of LTPA on psychological distress may also be beneficial when a long duration of time was spent in severely intensive OPA.

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