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

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). Kesamie-mi 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,
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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 569 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 (m²). 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 (≥6 MET for non-sedentary activities and ≥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, ≥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, where PA = $\sum$ Intensity of PA $\times$ hours spent in PA, PA denotes sleeping, five sedentary activities, and three non-sedentary activities |
| Leisure-time physical activity | LTPA | MET-hours/week | $\sum$ (MET of LTPA $\times$ hours spent in LTPA per week) where $j = 1, 2, 3$ denotes moderate, hard, severe LTPA |
| Occupational physical activity | OPA | MET-hours/day | $\sum$ (MET of OPA $\times$ hours spent in OPA per day) where $j = 1, 2, 3$ denotes moderate, hard, severe OPA, OPA denotes the difference of non-sedentary activity and LTPA |
| 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 |

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/m² 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-

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.
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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) | 4.32 (0.02)   | <0.001  |
| Quintile 1                                           | 4.02'       | 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        | 32.3          |         |
| 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.

between 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 = 0.05 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).

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
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 OPA 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).

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-
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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 descriptions of the type and intensity of physical activity.
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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