Association of Regular Leisure-Time Physical Activity with Body Mass Index and Obesity Risk in Taiwanese Young Adults

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Research Article

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Abstract

Background: The purpose of this study was to determine the association of regular leisure-time physical activity with body mass index and obesity risk in Taiwanese young adults.

Methods: A total of 10,802 young adults (18-44 years) were enrolled into this national telephone survey. The questionnaire data of this survey includes socio-demographic characteristics, zip code of residence, leisure-time physical activity (LTPA) behaviors, self-reported health status, and self-evaluations (including height, body weight, and body mass index [BMI]).

Results: When using non-regular LTPA as the baseline, participants in regular LTPA group exhibited the lower risks of overweight and underweight (OR, 0.837; 95% CI 0.738–0.948, OR, 0.732; 95% CI 0.611-0.876). But there was no significant relationship between the regular LTPA and obesity risk when using non-regular LTPA as the baseline after adjusting for potential confounders.

Conclusions: The study results revealed that regular LTPA effectively lowered the risks of underweight and overweight. However, for people with obesity, regular LTPA was unable to significantly decrease their obesity risk.

Background

Weight management is a major health topic worldwide. According to the World Health Organization, approximately 1.9 billion (39%) adults are overweight and more than 600 million (13%) are obese worldwide [1]. In Taiwan, the prevalence of obesity and morbid obesity (body mass index [BMI] > 35 kg/m^2) is approximately 11.8–22.1% and 0.4–1.4%, respectively [2]. Obesity can cause problems such as cardiovascular diseases, type 2 diabetes, cancer, osteoarthritis, and sleep apnea [3, 4], thus compromising the quality of life.

Similarly, being underweight (BMI < 18.5 kg/m^2) substantially increases mortality rates [5], triggers abnormal mental and physical health behavior, and lowers patients’ self-reported health [6]. A meta-analysis concluded that anorexia nervosa increases the mortality rates, which was significantly higher than the increase caused by bulimia [7]. Being underweight may be accompanied by malnutrition, which considerably increases the risks of infection [8]. In Taiwan, approximately 3.7–8.7% individuals are underweight [2]. Thus, weight management is crucial in lowering social and economic burden.

Physical activity is effective for weight management. Increasing the amount of leisure-time physical activity (LTPA) can reduce abdominal and visceral fat [9, 10], and the amount of physical activity and fat reduction are significantly and positively correlated [11]. According to the United States National Academy of Medicine, 150 min of moderate-intensity exercise per week can effectively improve the health status of adults with obesity [12]. However, whether such exercise amount and intensity are equally effective in improving the health of people who are underweight and whether LTPA can mitigate the risk factors of obesity and being underweight remain indeterminate. The purpose of this study was to
determine the association of regular leisure-time physical activity with body mass index and obesity risk in Taiwanese young adults.

Methods

Study sample and data collection procedures

The cross-sectional study data were obtained from the national-wide survey for children and adolescents (13–17 years), adults (18–64 years), and older adults (65 years and older) through the Taiwan National Physical Activity Survey (TNPAS) conducted by the Sports Administration, Ministry of Education in Taiwan. Recruitment was conducted by random-digit-dialing to the proportional-stratified sampling with multiple factors (e.g., age, gender, and geographic districts), and the detailed procedure has been described elsewhere [13]. Citizens aged over 13 years and stratified by 22 cities/counties across the country were selected to become the sampling population. The sample size of each city/county was determined by its proportion to the country population in Taiwan. The total sample size was 25,526 in 2020, with sampling errors of 3–5% and confidence intervals (CI) of 95%, which allowed for achieving a sufficient sample size and statistical power. Subsequently, a two-month telephone interview (CATI) was conducted by a computer-assisted system from August to October in 2020. To ensure the quality of data collection, a group of well-trained and experienced interviewers was employed in the CATI. The following data were collected through the telephone survey by socio-demographic characteristics (i.e., age, gender, education, and occupation), physical activity behaviors, self-reported health status, and self-evaluations (e.g., body height and body weight), and zip code of residence. Finally, a total of 10,802 young adults (18–44 years) was selected in this study. The participants were fully informed about the objective, procedure, and content of this study. This study was conducted under the Declaration of Helsinki, and all procedures have been approved by the Institutional Review Board of the Fu Jen Catholic University in Taiwan (FJU-IRB C109085). The oral consent was given before the interview. All relevant information was contained in the de-identified secondary dataset and was released for public research purposes.

Data collection

Multiple demographic characteristics of participants were required and recorded in this study, and they are age, gender, education, occupation, and self-reported health status. The age of participants was divided into 18–24, 25–29, 30–34, 35–39, and 40–44 years, and education was categorized by the elementary school or lower, junior or senior high school, and college or higher. Detailed categories of occupation included white collar, government servant, blue-collar, owner/manager, specialists, student, housewife, retired, free-lancer, jobless, and others. The self-reported health status contained excellent or good, fair, and very bad or poor.

Self-Reported Anthropometrics and Obesity Status

Both body height and weight were considered as self-reported anthropometric variables that were used to calculate BMI (kg/m²). In this study, the obesity status was defined by the following classes from Taiwan
Ministry of Health, and Welfare, Health Promotion Administration: (1) underweight (BMI < 18.5 kg/m²), (2) normal weight (18.5 ≤ BMI < 24 kg/m²), (3) overweight (24 ≤ BMI < 27 kg/m²), and (4) obese (BMI ≥ 27 kg/m²) [14].

**LTPA Assessment**

A series of questions through a CATI was utilized to determine either regular or non-regular LTPA in this study. The process of a CATI with the step-by-step questions as described in the following: First, the participant’s current LTPA participation was asked by the following question, “Have you taken part in any LTPA in the past month?” Second, both frequency and duration of LTPA participation were asks by the following questions when the respondent provided a positive response, “How many times do you participate in LTPA per week? “; ”How many minutes do you usually spend at one time?” Third, the LTPA intensity was assessed by the description of breathing and sweating status from the participant, and those questions included "When you are doing LTPA, you usually feel....”. And then, the following structural answers were selected and described by the respondent, "No changes in my breath and sweating," "I breathe faster but do not sweat," "I breathe normally but sweat," "I breathe quickly and sweat." When the respondent indicated they usually breathed quickly and sweated that was considered to engage in moderate-intensity LTPA. Finally, regular and non-regular LTPA groups were defined by the following conditions: (1) Regular LTPA group: participants who reported breathing quickly and sweating by participating in 150–300 min per week of moderate-intensity LTPA or 75–150 min per week of vigorous-intensity LTPA. (2) Non-regular LTPA group: the rest of the participants.

**Statistical analysis**

SAS 9.4 (SAS Institute, Cary, NC, USA) was utilized to perform multiple statistical analyses in this study including student’s t-test, chi-square test, and multiple linear regression analysis. Continuous variables were analyzed through the student’s t-test and categorical variables were analyzed by using the chi-square test. BMI was a dependent variable and used to examine the relationship between regular LTPA and BMI after the adjustment of potential confounders by using multiple linear regression analysis. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were applied on obese, overweight, or underweight were calculated from unconditional logistic regression models based on regular LTPA. In this study, test values were presented as means ± standard deviation (SD) or frequency percentages, and test results were evaluated with two-tailed and statistically significant at p < 0.05.

**Results**

Table 1 shown the result of the demographic characteristics. There were 10,802 data were dichotomized into groups regarding their Leisure Time Physical Activity (LTPA) status and most of participants (76%) were classified into the non-regular LTPA group. Except BMI, the significant differences were shown between groups (p < 0.05) on all relevant variables include age, gender, height, body weight, obese status, education, occupation and self-reported health status. Participants who were in non-regular LTPA group, the rates fo overweight (19.50%) and obese (15.00%) are higher than regular LTPA group and 18%
participants said that their health status were very bad or poor which were higher than regular LTPA group (11.00%) too.
Table 1
Demographic characteristics

| Variables                  | LTPA Status                  |  p-value |
|----------------------------|------------------------------|----------|
|                            | Regular LTPA (n = 2,592)     | Non-regular LTPA (n = 8,210) |
| Age (y)b                   | <0.0001*                     |          |
| 18–24                      | 809 (31.20%)                 | 1598 (19.50%) |
| 25–29                      | 480 (18.50%)                 | 1412 (17.20%) |
| 30–34                      | 443 (17.10%)                 | 1429 (17.40%) |
| 35–39                      | 403 (15.50%)                 | 1880 (22.90%) |
| 40–44                      | 457 (17.60%)                 | 1891 (23.00%) |
| Gender (% men)b            | <0.0001*                     |          |
| 1,698 (65.5%)              | 4,001 (48.7%)                |          |
| Height (cm)a               | <0.0001*                     |          |
| 169.26 ± 8.68              | 165.75 ± 8.31                |          |
| Body weight (kg)a          | <0.0001*                     |          |
| 66.49 ± 13.26              | 63.80 ± 14.07                |          |
| BMI (kg/m²)a               | 0.960                        |          |
| 23.08 ± 3.55               | 23.07 ± 4.05                 |          |
| Obese Status (%)b          | <0.0001*                     |          |
| Underweight                | 184 (7.10%)                  | 737 (9.00%) |
| Normal weight              | 1475 (56.90%)                | 4285 (52.20%) |
| Overweight                 | 485 (18.70%)                 | 1598 (19.50%) |
| Obese                      | 353 (13.60%)                 | 1230 (15.00%) |
| Education (%)b             | <0.0001*                     |          |
| Elementary school or lower | 2 (0.10%)                    | 30 (0.40%) |
| Junior or senior school    | 553 (21.40%)                 | 2547 (31.10%) |
| College or higher          | 2035 (78.60%)                | 5608 (68.50%) |

Abbreviations: BMI, body mass index; LTPA, leisure time physical activity.

*p < 0.05.

Values expressed as mean ± standard deviation.

Values expressed as n (percentage).
| Variables                          | LTPA Status     | p-value       |
|-----------------------------------|-----------------|---------------|
| Occupation (%)<sup>b</sup>        |                 | <0.0001*      |
| White collar                      | 588 (22.80%)    | 2033 (24.90%) |
| Government servant                | 228 (8.80%)     | 497 (6.10%)   |
| Blue collar                       | 380 (14.70%)    | 1970 (24.10%) |
| Owner/manager                     | 139 (5.40%)     | 337 (4.10%)   |
| Specialists                       | 289 (11.20%)    | 812 (10.00%)  |
| Student                           | 616 (23.90%)    | 895 (11.00%)  |
| Housewife                         | 80 (3.10%)      | 641 (7.90%)   |
| Retired                           | 1 (0.00%)       | 13 (0.20%)    |
| Free lancer                       | 104 (4.00%)     | 248 (3.00%)   |
| Jobless                           | 119 (4.60%)     | 636 (7.80%)   |
| Other                             | 36 (1.40%)      | 78 (1.00%)    |
| Self-reported health status (%)<sup>b</sup> |                 | <0.0001*      |
| Excellent or good                 | 2185 (85.00%)   | 6071 (75.50%) |
| Fair                              | 103 (4.00%)     | 520 (6.50%)   |
| Very bad or poor                  | 282 (11.00%)    | 1449 (18.00%) |

Abbreviations: BMI, body mass index; LTPA, leisure time physical activity.

<sup>*</sup><sup>p</sup><sub>&lt; 0.05</sub>.

<sup>a</sup>Values expressed as mean ± standard deviation.

<sup>b</sup>Values expressed as n (percentage).

The comparison between BMI and LTPA status among middle-aged and older adults were presented in Table 2. The BMI of the regular LTPA group were significant higher than non-regular LTPA group in age 18–24 (22.01 ± 3.02; 21.53 ± 3.15) and 40–44 (23.85 ± 2.97; 23.50 ± 3.40) group in pooled group (<sup>p</sup><sub>&lt; 0.05</sub>). However in difference gender, the significant difference between regular LTPA and non-regular LTPA were found only in women in age 18–24, 25–29 and 30–34 and regular LTPA had higher BMI in age 18–24 (21.32 ± 2.78; 20.75 ± 2.91) and 25–29 (21.59 ± 2.75; 20.97 ± 3.06).
Table 2
The comparison between BMI and LTPA status among young adults in Taiwan

| Variables      | LTPA Status       |  p-value |
|----------------|-------------------|----------|
|                | Regular LTPA | Non-regular LTPA |
| **Men (n = 5,326)\(^a\)** |          |            |
| 18–24          | 22.31 ± 3.08    | 22.30 ± 3.19  | 0.989   |
| 25–29          | 22.74 ± 2.56    | 22.91 ± 3.12  | 0.375   |
| 30–34          | 24.24 ± 3.00    | 24.38 ± 3.45  | 0.538   |
| 35–39          | 24.45 ± 3.05    | 24.35 ± 3.26  | 0.689   |
| 40–44          | 24.96 ± 2.59    | 24.86 ± 3.25  | 0.607   |
| **Women (n = 4,716)\(^a\)** |          |            |
| 18–24          | 21.32 ± 2.78    | 20.75 ± 2.91  | 0.009*  |
| 25–29          | 21.59 ± 2.75    | 20.97 ± 3.06  | 0.022*  |
| 30–34          | 20.86 ± 2.21    | 22.00 ± 3.45  | <0.0001*|
| 35–39          | 21.61 ± 3.14    | 21.83 ± 2.99  | 0.414   |
| 40–44          | 21.97 ± 2.61    | 22.38 ± 3.10  | 0.078   |
| **Pooled (n = 10,041)\(^a\)** |          |            |
| 18–24          | 22.01 ± 3.02    | 21.53 ± 3.15  | <0.0001*|
| 25–29          | 22.34 ± 2.68    | 22.04 ± 3.24  | 0.050   |
| 30–34          | 23.21 ± 3.19    | 23.12 ± 3.65  | 0.626   |
| 35–39          | 23.38 ± 3.38    | 23.03 ± 3.37  | 0.074   |
| 40–44          | 23.85 ± 2.97    | 23.50 ± 3.40  | 0.033   |

Abbreviations: BMI, body mass index; LTPA, leisure time physical activity.

\( ^* \) \( p < 0.05 \).

\(^a\) Values expressed as n (percentage).

Table 3 compared the overweight and obesity prevalence between regular LTPA and non-regular LTPA among middle-age and older adults. The result indicated that the significant difference between regular LTPA and non-regular LTPA were found in age 18–24 and 25–29 in pooled group and the overweight (17.20%) and obesity (09.40%) prevalence of non-regular LTPA group were higher than regular LTPA (14.20%; 07.10%) in age 25–29. But in age 18–24, the obesity prevalence of regular LTPA (07.50%) were
higher than non-regular LTPA group (06.40%). In addition, both men (12.00%; 08.80%) and women (06.20%; 03.80%) the obesity prevalence of non-regular LTPA group were significant higher than regular LTPA in age 25–29. On the contrary, the overweight prevalence of non-regular LTPA group were significant lower than regular LTPA in women (08.90%; 12.70%). The overweight (11.00%; 09.50%) and obesity (11.30%; 00.00%) prevalence of non-regular LTPA were significant higher than regular LTPA group in age 30–34 group in women, in men the significant difference were found in age 35–39 group too (overwight:31.30%; 29.10%, obesity:21.70%; 20.90%).
Table 3
The comparison between overweight/obesity prevalence and LTPA status among young adults in Taiwan

| Variables | LTPA Status | p-value |
|-----------|-------------|---------|
|           | Regular LTPA | Non-regular LTPA |
| Men (n = 5,326)<sup>a</sup> |             |         |
| 18–24     |             |         |
| Underweight | 60(11.00%) | 88(12.00%) | 0.130 |
| Normal weight | 346(63.50%) | 427(58.30%) |         |
| Overweight | 87(16.00%) | 152(20.80%) |         |
| Obesity    | 52(09.50%) | 65(08.90%) |         |
| 25–29     |             |         |
| Underweight | 13(04.40%) | 51(07.10%) | <0.0001* |
| Normal weight | 211(71.80%) | 411(56.90%) |         |
| Overweight | 44(15.00%) | 173(24.00%) |         |
| Obesity    | 26(08.80%) | 87(12.00%) |         |
| 30–34     |             |         |
| Underweight | 7(02.40%) | 31(04.90%) | 0.078 |
| Normal weight | 134(46.20%) | 254(40.50%) |         |
| Overweight | 74(25.50%) | 193(30.80%) |         |
| Obesity    | 75(25.90%) | 149(23.80%) |         |
| 35–39     |             |         |
| Underweight | 0(00.00%) | 32(03.90%) | 0.011* |
| Normal weight | 117(50.00%) | 359(43.20%) |         |
| Overweight | 68(29.10%) | 260(31.30%) |         |
| Obesity    | 49(20.90%) | 180(21.70%) |         |
| 40–44     |             |         |
| Underweight | 2(00.80%) | 13(01.60%) | 0.126 |
| Normal weight | 88(35.10%) | 281(35.50%) |         |
| Overweight | 107(42.60%) | 283(35.70%) |         |
| Obesity    | 54(21.50%) | 215(27.10%) |         |
| Women (n = 4,716)<sup>a</sup> |             |         |

Abbreviations: LTPA, leisure time physical activity.

*<i>p</i> < 0.05.

<sup>a</sup>Values expressed as n (percentage).
| Variables | LTPA Status |       |       |       |
|-----------|-------------|-------|-------|-------|
|           |             | Regular LTPA | Non-regular LTPA | p-value |
| 18–24     | Underweight | 34(14.70%) | 155(21.30%) | 0.092  |
|           | Normal weight | 152(65.80%) | 450(61.90%) |       |
|           | Overweight | 38(16.50%) | 93(12.80%) |       |
|           | Obesity | 7(03.00%) | 29(04.00%) |       |
| 25–29     | Underweight | 19(12.00%) | 121(20.30%) | 0.034* |
|           | Normal weight | 113(71.50%) | 384(64.50%) |       |
|           | Overweight | 20(12.70%) | 53(08.90%) |       |
|           | Obesity | 6(03.80%) | 37(06.20%) |       |
| 30–34     | Underweight | 17(13.50%) | 76(10.80%) | 0.001* |
|           | Normal weight | 97(77.00%) | 470(67.00%) |       |
|           | Overweight | 12(09.50%) | 77(11.00%) |       |
|           | Obesity | 0(00.00%) | 79(11.30%) |       |
| 35–39     | Underweight | 21(14.90%) | 95(10.40%) | 0.135  |
|           | Normal weight | 97(68.80%) | 632(69.10%) |       |
|           | Overweight | 11(07.80%) | 122(13.30%) |       |
|           | Obesity | 12(08.50%) | 65(07.10%) |       |
| 40–44     | Underweight | 11(07.20%) | 74(07.70%) | 0.245  |
|           | Normal weight | 110(71.90%) | 617(63.90%) |       |
|           | Overweight | 23(15.00%) | 191(19.80%) |       |
|           | Obesity | 9(05.90%) | 84(08.70%) |       |
| Pooled (n = 10,041)² |             |         |         |       |
| 18–24     | Underweight | 94(12.10%) | 243(16.70%) | 0.025* |
|           | Normal weight | 498(64.30%) | 877(60.10%) |       |

Abbreviations: LTPA, leisure time physical activity.

* *p < 0.05.

²Values expressed as n (percentage).
| Variables | LTPA Status | p-value |
|-----------|-------------|---------|
|           | Regular LTPA | Non-regular LTPA |
|           |              |          |
| Overweight| 125(16.10%)  | 246(16.90%) |
| Obesity   | 58(07.50%)   | 93(06.40%)  |
| 25–29     |              |          |
| Underweight| 32(07.10%)  | 172(13.10%) |
| Normal weight| 324(71.70%) | 795(60.40%) |
| Overweight| 64(14.20%)   | 226(17.20%) |
| Obesity   | 32(07.10%)   | 124(09.40%) |
| 30–34     |              |          |
| Underweight| 24(05.80%)  | 107(08.10%) |
| Normal weight| 231(55.50%) | 724(54.50%) |
| Overweight| 85(20.40%)   | 269(20.30%) |
| Obesity   | 76(18.30%)   | 228(17.20%) |
| 35–39     |              |          |
| Underweight| 21(05.60%)  | 126(07.20%) |
| Normal weight| 214(57.10%) | 992(56.80%) |
| Overweight| 79(21.10%)   | 382(21.90%) |
| Obesity   | 61(16.30%)   | 245(14.00%) |
| 40–44     |              |          |
| Underweight| 12(03.00%)  | 87(04.90%)  |
| Normal weight| 199(49.30%) | 898(51.10%) |
| Overweight| 130(32.20%)  | 474(27.00%) |
| Obesity   | 63(15.60%)   | 299(17.00%) |

Abbreviations: LTPA, leisure time physical activity.

*<p><.05.

Values expressed as n (percentage).

Table 4 indicated the result of the multivariate regression for regular LTPAs to BMI scores. There is positive relation between regular LTPA and BMI scores ($\beta = 0.014$, $p < 0.05$), the more regular LTPA adults do, the more BMI scores they get. However, adjusts for age, gender, self-reported health status, occupation, education the explanatory power decrease ($\beta = 0.005$). The result of the multivariate logistic regression for regular LTPAs to difference Obese status (obesity, overweight, underweight) were shown in Table 5. In model 2, when using non-regular LTPA as the baseline, participants in regular LTPA group exhibited the lower risks of overweight and underweight (OR, 0.837; 95% CI 0.738–0.948, OR, 0.732; 95%
CI 0.611–0.876). But there was no significant relationship between the regular LTPA and obesity risk when using non-regular LTPA as the baseline in Model 2.

Table 4 Multivariate regression for regular LTPAs to BMI scores

| Variables       | Model 1 (unadjusted) | Model 2 (adjusted<sup>a</sup>) |       |       |
|-----------------|----------------------|--------------------------------|-------|-------|
|                 | β        | SE   | p-value | β      | SE   | p-value |
| Regular LTPA    | 0.014    | 0.078 | 0.172   | 0.005  | 0.074 | 0.588   |
| Non-regular LTPA| Ref.    | -    | -       | Ref.   | -    | -       |

Abbreviations: LTPA, leisure time physical activity; SE, standard error.

<sup>a</sup>p < 0.05.

<sup>a</sup>Adjusted for age, gender, self-reported health status, occupation, and education.

Table 5 Multivariate logistic regression for regular LTPAs to underweight, overweight, and obesity risks.

| Variables | Model 1 (unadjusted) | Model 2 (adjusted<sup>a</sup>) |       |       |
|-----------|----------------------|--------------------------------|-------|-------|
|           | OR  | 95% CI     | P-value | OR  | 95% CI     | P-value |
| Underweight |     |            |         |     |            |         |
| Regular LTPA | 0.726 | 0.611-0.862 | <0.0001* | 0.732 | 0.611-0.876 | 0.001* |
| Non-regular LTPA | Ref. | -    | -       | Ref. | -    | -       |
| Overweight |     |            |         |     |            |         |
| Regular LTPA | 0.881 | 0.783-0.991 | 0.035* | 0.837 | 0.738-0.948 | 0.005* |
| Non-regular LTPA | Ref. | -    | -       | Ref. | -    | -       |
| Obesity |     |            |         |     |            |         |
| Regular LTPA | 0.832 | 0.729-0.950 | 0.007* | 0.880 | 0.759-1.020 | 0.090 |
| Non-regular LTPA | Ref. | -    | -       | Ref. | -    | -       |

Abbreviations: CI, confidence interval; LTPA, leisure time physical activity; OR, odds ratio.

<sup>*</sup>p < 0.05.

<sup>a</sup>Adjusted for age, gender, self-reported health status, occupation, and education.
Discussion

On the basis of the suggestions made by the American College of Sports Medicine (ACSM), this study defined $\geq 150$ min of moderate-intensity exercise or $\geq 75-150$ min of high-intensity exercise per week as having the habit of exercising regularly or having nonregular LTPA. The study results revealed that regular LTPA effectively lowered the risks of underweight and overweight. However, for people with obesity, regular LTPA was unable to significantly decrease their obesity risk.

According to the study results, regular LTPA reduced the odds of being underweight by 26.8%. The causes of being underweight include anorexia nervosa, cognitive behavior [15], and being picky eaters [16], which result in insufficient calorie intake for extended periods of time. Studies have indicated that 120-min aerobic exercise per week can effectively increase the weight and fitness of patients who are underweight [17]. For patients with anorexia nervosa, exercise intervention can effectively improve their nutritional status [18] and quality of life [19]. Additionally, exercise intervention can improve their weight and eating disorder [20] considerably more than that achieved with traditional cognitive–behavioral therapy.

Although this study did not explore the specific causes of becoming underweight, the multivariate logistic regression analysis (adjusted for variables such as age, gender, self-reported health status, occupation, and education) found that exercise effectively decreased the odds of being underweight, suggesting that developing regular exercise habits may be key to lowering the odds of being underweight.

The current study indicated that LTPA can effectively diminish the odds of being overweight. LTPA can successfully reduce abdominal and visceral fat [9, 10], and the amount of physical activity and fat reduction are significantly and positively correlated [11]. Sedentary lifestyle and minimal physical activity are the main causes of increasing obesity prevalence [21]. In the United Kingdom, decreased physical activity level has been found to be the primary cause of high obesity prevalence [22]. Consistently, the present study discovered that regular LTPA can effectively lower the odds of being overweight.

Although LTPA could reduce the odds of being overweight considerably, it was unable to lower the odds of obesity; this may be because of the definition of LTPA. The ACSM asserted that 150 min of moderate-intensity exercise per week can effectively maintain people’s weight and health status. However, 150–200 min of moderate-intensity exercise per week can only achieve minimal reduction in body weight. Without dietary intervention, $>250$ min of moderate-intensity exercise per week is required to show any pronounced effect [12]. Other review-based studies have also indicated that 150 min of moderate-intensity exercise is ineffective in reducing weight [23], and recommended that 150–300 min of moderate-intensity or 75–150 min of high-intensity exercise per week [24] for weight loss. Therefore, for patients with obesity, exercise intervention may be insufficient, and dietary intervention or cognitive–behavioral therapy may be necessary.

This study had a sufficient sample size similar to those of previous studies on physical activity and BMI [25–27], and used questionnaires with favorable reliability and validity which have also been used in other studies [26]; thus, the sample size, study reliability, and study validity were representative of the overall population.
Although this study incorporated various intervening variables, it still had the following limitations: First, the data were limited to Taiwan. Future studies should investigate other ethnic groups, countries, and people with different financial statuses. Second, factors other than those covered in the questionnaires may have caused the participants to be underweight or overweight/obese, which were not examined in this study. Future studies should include other factors such as dietary habits, energy intake, and nutritional intake, particularly for people who are underweight.

**Conclusions**

In summary, this study found that 150 min of LTPA per week effectively lowered the odds of being underweight and overweight but was significantly reducing the risk of obesity (BMI $\geq 27$ kg/m$^2$). Future studies may investigate the effects of a combined approach of physical activity and dietary control on obesity.

**Abbreviations**

ACSM: American College of Sports Medicine; BMI: Body mass index; CATI: two-month telephone interview; CI: confidence interval; LTPA: Leisure-time physical activity; OR: odds ratio; SD: standard deviation; TNPAS: Taiwan National Physical Activity Survey.

**Declarations**

**Ethics approval and consent to participate:** The design and protocol of this study was approved by the Institutional Review Board of Fu Jen Catholic University in Taiwan (FJU-IRB C109085). The informed consent was obtained from all subjects involved in this study via CATI based survey. The present study was conducted according to the guidelines of the Declaration of Helsinki.

**Consent for publication:** Not applicable.

**Availability of data and material:** The raw data are not publicly available due to restrictions ethical.

**Competing interests:** The authors declare that they have no competing interests

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**Author Contributions:** C.L. participated in the design, conducted the statistical analyses, interpreted the data, and drafted the manuscript. S.-W. L. and P.-F. L. helped to manage and analyze the data, assisted in data interpretation. C.-C, H. supervised the study and critically reviewed and revised the manuscript. All authors have read and agreed to the published version of the manuscript.

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**References**

1. World Health Organization. World Health Organization obesity and overweight fact sheet.WHO, 2016. Available online: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight (accessed on 10 June 2021).

2. Chang, H.C.; Yang, H.C.; Chang, H.Y.; Yeh, C.J.; Chen, H.H.; Huang, K.C.; Pan, W.H. Morbid obesity in Taiwan: prevalence, trends, associated social demographics, and lifestyle factors. *PLoS One, 2017, 12*(2), e0169577.

3. Jehan, S.; Myers, A.K.; Zizi, F.; Pandi-Perumal, S.R.; Jean-Louis, G.; McFarlane, S.I. Obesity, obstructive sleep apnea and type 2 diabetes mellitus: Epidemiology and pathophysiologic insights. *Sleep Med. Disord., 2018, 2*(3), 52.

4. Duclos, M. Osteoarthritis, obesity and type 2 diabetes: The weight of waist circumference. Ann. Phys. Rehabil. Med., **2016**, **59**(3), 157-160.

5. Flegal, K.M.; Graubard, B.I.; Williamson, D.F.; Gail, M.H. Excess deaths associated with underweight, overweight, and obesity. *JAMA, 2005*, **293**(15), 1861-1867.

6. Lorem, G.F.; Schirmer, H.; Emaus, N. What is the impact of underweight on self-reported health trajectories and mortality rates: a cohort study. *Health Qual. Life Outcomes, 2017, 15*(1), 1-14.

7. Arcelus, J.; Mitchell, A.J.; Wales, J.; Nielsen, S. Mortality rates in patients with anorexia nervosa and other eating disorders: a meta-analysis of 36 studies. *Arch. Gen. Psychiatry, 2011, 68*(7), 724-731.

8. Dobner, J.; Kaser, S. Body mass index and the risk of infection-from underweight to obesity. *Clin. Microbiol. Infect., 2018, 24*(1), 24-28.

9. Kay, S.; Fiatarone Singh, M. The influence of physical activity on abdominal fat: a systematic review of the literature. *Obes. Rev., 2006, 7*(2), 183-200.

10. Thompson, D.L.; Rakow, J.; Perdue, S.M. Relationship between accumulated walking and body composition in middle-aged women. *Med. Sci. Sports Exerc., 2004, 36*(5), 911-914.
11. Ross, R.; Janssen, I. Physical activity, total and regional obesity: dose-response considerations. *Med. Sci. Sports Exerc.*, 2001, 33(6 Suppl), S521-S527.

12. Donnelly, J.E.; Blair, S.N.; Jakicic, J.M.; Manore, M.M.; Rankin, J.W.; Smith, B.K. American College of Sports Medicine Position Stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Med. Sci. Sports Exerc.*, 2009, 41(2), 459-471.

13. Ku, P.W.; Fox, K.R.; McKenna, J.; Peng, T.L. Prevalence of leisure-time physical activity in Taiwanese adults: results of four national surveys, 2000–2004. *Prev. Med.*, 2006, 43(6), 454-457.

14. Health Promotion Administration, Ministry of Health and Welfare. Check Your Body Weight Every Day. Available online: https://www.hpa.gov.tw/Home/Index.aspx (accessed on 20 June 2021).

15. Dalle Grave, R.; Calugi, S.; Marchesini, G. Objective and subjective binge eating in underweight eating disorders: associated features and treatment outcome. *Int. J. Eat. Disord.*, 2012, 45(3), 370.

16. Viljakainen, H.T.; Figueiredo, R.A.; Rounge, T.B.; Weiderpass, E. Picky eating–A risk factor for underweight in Finnish preadolescents. *Appetite*, 2019, 133, 107-114.

17. Bratland-Sanda, S.; Martinsen, E.W.; Sundgot-Borgen, J. Changes in physical fitness, bone mineral density and body composition during inpatient treatment of underweight and normal weight females with longstanding eating disorders. *Int. J. Environ. Res. Public Health*, 2012, 9(1), 315-330.

18. Rizk, M.; Kern, L.; Lalanne, C.; Hanachi, M.; Melchior, J.C.; Pichard C; Mattar, L.; Berthoz, S.; Godart, N. High-intensity exercise is associated with a better nutritional status in anorexia nervosa. *Eur. Eat. Disord. Rev.*, 2019, 27(4), 391-400.

19. Thien, V.; Thomas, A.; Markin, D.; Birmingham, C.L. Pilot study of a graded exercise program for the treatment of anorexia nervosa. *Int. J. Eat. Disord.*, 2000, 28(1), 101-106.

20. Hay, P.; Touyz, S.; Arcelus, J.; Pike, K.; Attia, E.; Crosby, R.D.; Madden, S.; Wales, J.; Puma, M.L.; Heriseanu, A.I.; Young, S.; Meyer, C. A randomized controlled trial of the compulSive Exercise Activity TheraPy (LEAP): A new approach to compulsive exercise in anorexia nervosa. *Int. J. Eat. Disord.*, 2018, 51(8), 999-1004.

21. Prentice, A.M.; Jebb, S.A. Obesity in Britain: gluttony or sloth? *BMJ*, 1995, 311(7002), 437-439.

22. Millward, D.J. Energy balance and obesity: a UK perspective on the gluttony v. sloth debate. *Nutr. Res. Rev.*, 2013, 26(2), 89-109.

23. Swift, D.L.; McGee, J.E.; Earnest, C.P.; Carlisle, E.; Nygard, M.; Johannsen, N.M. The effects of exercise and physical activity on weight loss and maintenance. *Prog. Cardiovasc. Dis.*, 2018, 61(2), 206-213.

24. Piercy, K.L.; Troiano, R.P. Physical activity guidelines for Americans from the US department of health and human services: Cardiovascular benefits and recommendations. *Circ. Cardiovasc. Qual. Outcomes*, 2018, 11(11), e005263.

25. Huang, I.; Frangakis, C.; Wu, A. The relationship of excess body weight and health-related quality of life: evidence from a population study in Taiwan. *Int. J. Obes. (Lond)*, 2006, 30(8), 1250-1259.

26. Ho, C.C.; Lee, P.F.; Chen, H.L.; Tseng, C.Y.; Hsieh, X.Y.; Chiu, C.H. Poor health-related physical fitness performance increases the overweight and obesity risk in older adults from Taiwan. *BMC Geriatr*,
27. Lee, P.F.; Ho, C.C.; Yeh, D.P.; Hung, C.T.; Chang, Y.C.; Liu, C.C.; Tseng, C.Y.; Hsieh, X.Y. Cross-sectional associations of physical fitness performance level and sleep duration among older adults: Results from the national physical fitness survey in Taiwan. *Int. J. Environ. Res. Public Health*, 2020, 17(2), 388.