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RESEARCH ARTICLE

Health Benefits of Physical Exercise as a Lifestyle Habit in Asian Men and Women

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Abstract

Background: We evaluated how the intensity of physical exercise as a lifestyle habit is associated with a comprehensive array of health parameters.

Methods: Total body composition and bone scans were analyzed using dual energy X-ray absorptiometry (DXA). Exercise intensity scores were computed using the Metabolic Equivalent of Task (MET). Handgrip strength was measured using a dynamometer. Various hormones and metabolic parameters were measured and cognition function tests and data regarding general health and sexual functions were collected.

Results: The present study showed that regular physical exercise of enough intensity as a lifestyle habit has significant health benefits. The major health compartments including some domains of cognition, bone status, cardiovascular and metabolic health, total body fat and insulin levels were significantly improved due to regular physical exercises. Some aspects of sexual function, General lifestyle factors such as well-being, physical tone and strength, as well as sleep hygiene significantly benefited from regular physical exercise. Testosterone levels in men were higher due to regular exercises.

Conclusion: The results of the present study support the strategy of promoting regular physical exercise to mitigate increases in risks of the major diseases such as diabetes, metabolic and cardiovascular disorders, sexual dysfunctions, bone and muscular dysfunctions. The MET-min is an objective and practical tool to assess an individual's level of exercise intensity and promotion the attainment of at least > 1000 MET-min in order to attain the exercise associated health benefits.

Introduction

Studies have shown that a sedentary lifestyle is associated with increased health risks and that physical exercise can mitigate many of these risks [1-7]. Despite these findings, an active promotion of physical exercise rarely is a national priority and it is not among most physician's management modalities. A possible reason may be that many studies were experimentally based on evaluations of how short duration of physical exercise affects some health compartments. In these experimental settings, it is difficult to translate results to real life situations. It is also impractical and probably inappropriate to prescribe a single regime of physical exercise for everyone; a one size fits all, is most likely unworkable.

Many people do engage in regular physical exercise and sport as a lifestyle habit. The type, duration and intensity vary widely. Without a common index to quantify the exercise intensity of these varied exercise types and sport, it is difficult to evaluate how physical exercise is associated with the various health compartments.

In the present cross-sectional study, a biggest of its kind, the metabolic equivalent of task-minutes (MET-min), introduced earlier [8], was used to approximate and harmonize the intensity of various exercise types into a single index of exercise intensity. Using this index, the study sought answers to the following questions: is there any health benefits associated with regular physical exercise as a lifestyle habit; are the benefits in different health compartments associated with different thresholds of intensity of exercise and are there gender and age differences in how exercise impacts the various health compartments?

Subjects, Materials and Methods

Subjects

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versity Hospital of Singapore approved this study and each volunteer gave his/her written informed consent. The method was previously reported [9,10]. A large cohort of 531 Singaporean men and 1326 women, aged between 29y and 72y, were included in the analyses. As the primary objective of the study was to evaluate the determinants of the natural aging process, only men and women without a history of medical illnesses such as cancer, hypertension, thyroid dysfunction, diabetes, osteoporotic fracture, cardiovascular events, major sleep disorders, major joint surgery, or bone fracture were included in the study. Subjects were not paid for their participation. The cohort of men and women represented the diverse spectrum of people in Singapore, ranging from those with low to high levels of education, working and non-working men and women (retirees), and those in various types of vocation [10]. Their profiles were typical of Singapore, which is a highly urbanized city-state with no rural population.

Methodologies

General questionnaire: Each subject answered a self-administered and investigator-guided questionnaire. Questions asked included their medical, social, sex, exercise regime, and family history.

Physical exercise: Men and women in Singapore were engaged in a wide range of physical exercises and sports, and for the purpose of the present study, the exercises or sports will collectively be referred to as physical exercise (PE). The physical exercises involved ranged from casual walking, brisk walking, jogging, running, working out in the gymnasium, golfing, weight lifting, tennis, badminton, basketball, cycling, swimming, dancing, Tai Chi, Qigong, yoga, soccer, stretching and aerobic exercise.

Exercice intensity scores (MET-min) : The metabolic equivalents for task (MET) assigned to each physical exercise type was used to compute an approximation of the intensity of exercise expressed as metabolic equivalent for task-minutes per week (MET-min) as reported earlier [8,10]. For example, if a man jogs (jogging has a MET of 10.5) 4 times a week and each time for 30 min, his exercise intensity will be 1260 MET-min (10.5 × 30 × 4). On the other hand, if he brisk walks (brisk walk has a MET of 8.0) 4 time a week and each time for 45 min; his exercise score will be 1440 MET-min (8 × 45 × 4). Only when the physical exercise was carried out regularly for at least six months it was considered as a lifestyle habit. Everyone was given an exercise intensity score based on the exercise profile gathered from the returned questionnaire. An individual without a regular physical exercise regime was arbitrary given a MET-min score of zero.

Based on the intensity of exercise, men and women were classified into three groups. Group 1 (METGp1) consisted of those who were not involved in any physical exercise as a lifestyle habit and their MET-min was arbitrary set at "0", Group 2 (METGp2) consisted of those who had MET-min > 0 and 1250 MET-min and Group 3 (METGp3) consisted of those whose exercise intensity was > 1250 MET-min.

Biochemical and hormone measurements: An overnight 12 h fasting blood sample was collected in the morning between 9.00 am and 11.00 am in men and postmenopausal women. For premenopausal women, a blood sample was collected between Day 3 to Day 5 of their menstrual cycle. The sera were stored at -80 °C until analyses were performed. Serum levels of total cholesterol (TC) and triglycerides (TG), high-density lipoprotein-cholesterol (HDL), low-density lipoprotein cholesterol (LDL) and fasting glucose level (GLU) were measured by methods reported earlier [11]. Serum testosterone (T) and oestradiol (E2), dehydroepiandrosterone sulphate (DHEA/S), sex hormone binding globulin (SHBG) and cortisol (Cor) were measured by established radioimmunoassay methods reported earlier [9]. Serum concentrations of insulin-like growth factor-1 (IGF1), insulin like growth factor binding protein-3 (BP3) and thyroid stimulating hormone (TSH) were measured using immunoradiometric assay kits (Diagnostic Systems Laboratories, Inc., Webster, TX) as reported earlier [12,13]. Serum concentrations of insulin (INS) were measured in-house using the AxSYM platform from Abbott. Bioavailable testosterone (BioT) was calculated using the computer formula of Vermeulen, which is available on the ISSAM website [www.issam.ch].

Whole body DXA and bone scans: Each subject had a whole-body scan using the DXA Hologic, Bedford, MA, USA. The DXA scanner calculated the percent total body fat (PBF) automatically using the Siri formula. Total body and regional distribution in the trunk (Tk), abdomen (Abd), arms (Arm) and legs (Leg) of lean (L) and fat (F), expressed as mass and percent, were computed from the whole-body scan. Total bone mineral content (TBMC) and percent mineral content (PBMC) were also derived from the whole-body scan.

Spine and hip osteoporosis and osteopenia: Each subject underwent a lumber spinal scan at the L2-L4, and a scan of the hip (representing the femoral neck, shaft, and trochanter) using DXA. The DXA scanner computed the spine bone mineral density (Sbmd, the average BMD of L2-L4) and femoral neck bone mineral density (Hbmd). The T-scores for the spine and femoral neck were computed with reference to the bone mineral density (BMD) for young men and women established for the local population. According to the WHO guidelines, a T-score > -1.00 is normal, while T-scores < -1.00 to -2.50 denote osteopenia and T-scores of < -2.50 denote osteoporosis [14,15]. Hence, the following groups were identified: Spine osteopenia (SOsteopn) and spine osteoporosis (SOsteop) and as well as hip osteopenia (HOsteopn) and hip osteoporosis (HOsteop) and they were used in the analyses of incidence.

Handgrip strength (Grip): A handgrip dynamometer (Takei Scientific Instruments, Japan) was used to test the handgrip strength as reported earlier [15]. The purpose of this test was to measure the maximum isometric strength of the hand and forearm muscles. Also, as a rule, people with strong hands tend to be strong also elsewhere, so this test is often used as a general test of strength [16,17]. Each subject performed the handgrip test three times and the maximum score (Grip) of the three was used for the analysis. The handgrip strength was expressed as kilogram force (Kgf).

Well-being score (WBSc), well-being symptoms (WBsym): The well-being questionnaire contains 31 items regarding a wide variety of symptoms, such as vegetative symptoms, concentration deficit, fatigue, tiredness, dizziness, and symptoms of peripheral neuropathy. The subjects were asked to rate the frequency of occurrence of each symptom during the last 24 hours on a four-point scale with 0, denoting none and 3, frequent. This test was taken from the SPES package [18]. The individuals' sense of well-being is dependent on many factors including sleep; levels of stress at work and at home, any circadian rhythm disruption and the presence of emotional distress. A higher score, therefore, would reflect a greater sense of being unwell. A higher number of symptoms (WBSym) add up to a higher sense of being unwell.

Forced expiration capacity test (FEC): Subjects were asked to blow into an instrument to measure the forced expiratory volume using an instrument from Takei, Japan. The measurement was adjusted for gender and age of the subjects. The score was then set as a percent of the mean at the individual's age and gender group. It is a measure of tiredness or physical tone of the person at the time of testing. A lower percentage (FEC score) indicates a more tired or weaker physical state.

Blood Pressures

Brachial systolic (Sys) and diastolic (Dia) blood pressures were measured by trained clinical researchers using a standardized manual sphygmomanometer method and after the participants had rested for at least 5 min. Both blood pressures were recorded as millimeter of mercury (mmHg).

Cognitive function tests

The Swedish Performance Evaluation System (SPES) was developed over the last 40 years [18]. Two prospective tests from the SPES, the Symbol Digit for perceptual capacity and Digit Span for short-term memory were used in the study. The digit symbol and digit span tests were computer-based tests. All participants underwent a familiarization trial test before the actual scorings were recorded.

Symbol digit: The Symbol Digit is a test of perceptual capacity, which includes matching, memory and the speed of processing. In one row, a key to this coding task is given by the pairing of symbols with randomly arranged digits, 1 to 9. The task is to key in as fast as possible the digits corresponding to the symbols presented in random order in a second row. Each set consists of nine pairs of randomly arranged symbols and digits, and a total of 10 sets are presented. Performance is evaluated as the mean reaction time in milliseconds (RT) and the number of errors (Err) for the last 54 pairs of the test. Symbol digit tests the individual's ability to interpret and correctly match what he sees as well as the speed of his mental perception. It also involves hand-eye coordination. The two components of this test are reaction time (RT) and the number of errors (Err) [18].

Digit span: The Digit Span is a test of short-term memory capacity. In this test, a series of digits is presented on the computer screen. The digits are presented one at a time with a 1-second presentation time, and the task is to reproduce the series on the keyboard. Depending on the answer, the length of the following series is either increased or decreased. The test starts with a series of three digits and it is terminated after six incorrect answers. Performance is evaluated as the maximum string of numbers (DSpan) that the subject could remember successfully. A longer DSpan indicates a better short-term visual memory [18].

Obesity

Definitions of general obesity (GOb) and abdominal obesity (AbO)

Percent total body fat (PBF) computed from the DXA-whole body scan was used to define general obesity. General obesity (GO) was defined when the PBF is ≥ 25% for men and ≥ 35% for women [19]. As reported earlier, abdominal obesity was defined when the percent abdominal fat is > 25% and > 21.8% in men and women, respectively [20,21].

Metabolic Syndrome (MetS) Groupings

The most commonly used NCEP ATPIII definition of metabolic syndrome (MetS) was used for the purpose of the present study [22]. According to the recommendations of the NCEP ATP III [22], the 5 risk factors of the MetS are:

- High density lipoprotein cholesterol (HDL) < 1.03 mmol/l
- Fasting glucose level (GLU) > 5.6 mmol/l
- Systolic blood pressure/diastolic blood pressure - B/P > 130/ > 85 mmHg
- Triglyceride level (TG) > 1.7 mmol/l
- For the present study, the risk factor of waist circumference was replaced by a PBF of ≥ 25% for men and ≥ 35% for women to defined obesity.

An individual was considered to have metabolic syndrome (MetS) when he/she has 3 or more of the above 5 metabolic syndrome risk factors.

Indices of Insulin resistance

Besides high levels of insulin as indicative of possible insulin resistance, the Homeostasis Model Assessment (HOMA) was established as a measure of insulin resistance. As suggested by Matthews, et al. [23] multiplying fasting insulin by fasting glucose levels and dividing by 22.5 compute HOMA. A HOMA value of > 2.8 computed from a single fasting blood sample correlated well with other measures of insulin resistance.

Surveys sleep and sexual activities

In the general questionnaire, subjects were asked to rate their duration of sleep, easiness of falling asleep and their sexual functions. The scores were based on the following questions:

Sleep duration per night (SlpD) Score

- < 4 h 1
- 4-6 h 2
- 6-8 h 3
- > 8 h 4

Do you have problem falling asleep? (Fallaslp) Score

- No 1
- Yes 2

Sexual activities

Subjects were asked, on an average,

1. How many times they had coitus with their partner per month (CoitalF)
2. Whether they self-masturbate (Masturbate) Score
   - No 1
   - Yes 2
3. If they do, how many times per month (No. Times)

Statistical Analysis

Statistical analyses were performed using SPSS for Windows version 21.0. Basic descriptive statistics as well as comparison of means using the Multivariate analyses of the General Linear Model coupled with the Bonferroni as the Post-Hoc test for multiple means were used on continuous measurements. Comparisons were carried out among the three MET groups and significance differences were denoted when the p value was ≤ 0.05. For non-parametric measures such as the incidence of osteopenia and osteoporosis, easiness of falling asleep, number of persons who were engaged in masturbation, the number of persons who were obese, cross-tab analyses with the three MET groups were computed and the Fisher's exact test was used for statistical analyses.

Results

In general, more men (71.4%) than women (66.7%) were engaged in regular physical exercise as a lifestyle habit and more men (25.8%) than women (9.5%) were involved in more intense physical exercise (METGp3) (Table 1 and Table 2). The average physical exercise intensity of men was higher than that of women. Furthermore, older men and women in Singapore tend to exercise more intensely than younger men and women (Table 1 and Table 2).

The profile of physical exercise types showed a gender difference. More men (61.7%) were engaged in physical exercises, such as brisk walking, jogging, running, tennis, badminton, squash, soccer, gymnasium workout, that have a greater weight-bearing component than corresponding level in women (29.8%). Most women (70.2%) were engaged in less weight-bearing

Table 1: Characteristics of women in the three exercise intensity groups (METGp1-3).

	METGp1 n = 441	METGp2 n = 761	METGp3 n = 124	P values
Age (y)	49.4 ± 0.38	49.5 ± 0.32	51.2 ± 0.54	NS
METmin	0	467 ± 6	1842 ± 30	1, 2 vs. 3 (< 0.001, < 0.001), 2 vs. 3 (< 0.001)
RT (msec)	2515 ± 29	2424 ± 18	2471 ± 25	1 vs. 2 (0.010)
PBF (%)	29.0 ± 0.24	28.6 ± 0.18	27.3 ± 0.48	1, 2 vs. 3 (0.003, 0.017)
PLM (%)	58.4 ± 0.23	58.7 ± 0.18	60.2 ± 0.45	1, 2 vs. 3 (0.001, 0.007)
HDL (mmol/L)	1.66 ± 0.018	1.65 ± 0.014	1.74 ± 0.010	2 vs. 3 (0.034)
TC/HDL	3.59 ± 0.046	3.59 ± 0.035	3.35 ± 0.075	1, 2 vs. 3 (0.037, 0.024)
LegL (g)	11000 ± 80	11124 ± 82	11310 ± 86	1 vs. 3 (0.027)
CoitalF	3.74 ± 0.18	4.41 ± 0.14	4.14 ± 0.33	1 vs. 2 (0.009)
SOsteop	16/441 (3.6%)	14/761 (1.8%)	3/124 (2.4%)	1 vs. 2 (0.044)
HOsteop	54/441 (12.2%)	94/761 (12.4%)	18/124 (14.5%)	NS
HOsteopn	245/441 (55.6%)	389/761 (51.1%)	61/124 (49.2%)	NS
HOMA+	40/441 (9.1%)	48/761 (6.3%)	3/124 (2.4%)	1, 2 vs. 3 (0.050, 0.006)

The parametric measures are presented as ± SE. METmin: Exercise intensity; RT: Retention time of the perceptual capacity test; PBF: Percent body fat; PLM: Percent lean mass; HDL: High density lipoprotein cholesterol; TC/HDL: Total cholesterol/HDL ratio; LegL: Leg lean mass; CoitalF: Coital frequency per month; SOsteop: Osteoporosis of the spine at L2-L4; HOsteop: Osteoporosis of the hip at the femoral neck; HOsteopn: Osteopenia of the hip at the femoral neck; HOMA: Homeostasis Model Assessment score.

Table 2: Characteristics of men in the three exercise intensity groups (METGp1-3).

	METGp1 n = 152	METGp2 n = 242	METGp3 n = 137	P values
Age (y)	49.1 ± 0.70	49.8 ± 0.60	53.2 ± 0.60	1, 2 vs. 3 (0.002, 0.004)
METmin	0	569 ± 20	2410 ± 92	1, 2 vs. 3 (< 0.001, < 0.001), 2 vs. 3 (< 0.001)
RT (msec)	2479 ± 39	2369 ± 27	2363 ± 24	1 vs. 2 (0.032)
Grip (Kgf)	37.5 ± 0.50	38.1 ± 0.30	39.2 ± 0.50	1 vs. 3 (0.036)
WBSc	19.5 ± 0.9	17.1 ± 0.60	15.0 ± 0.70	1 vs. 3 (0.001)
Sbmd (g/cm^2)	1.011 ± 0.015	1.033 ± 0.011	1.101 ± 0.016	1, 2 vs. 3 (< 0.001, 0.001)
Hbmd (g/cm^2)	0.818 ± 0.010	0.841 ± 0.008	0.893 ± 0.012	1, 2 vs. 3 (< 0.001, < 0.001)
TBMC (g)	2632 ± 30	2620 ± 22	2742 ± 30	1, 2 vs. 3 (0.030, 0.003)
PLM (%)	72.9 ± 0.46	73.9 ± 0.38	74.8 ± 0.31	1 vs. 3 (0.005)
PBMC (%)	3.92 ± 0.041	3.93 ± 0.030	4.06 ± 0.040	1, 2 vs. 3 (0.043, 0.024)
PBF (%)	18.7 ± 0.44	17.9 ± 0.28	16.7 ± 0.44	1, 2 vs. 3 (0.002, 0.050)
T (ng/ml)	5.08 ± 0.14	4.94 ± 0.12	5.45 ± 0.17	2 vs. 3 (0.036)
SHBG mmol/L	28.8 ± 0.86	28.8 ± 0.67	33.0 ± 0.94	1, 2 vs. 3 (0.003, 0.001)
INS (SI unit)	7.92 ± 0.34	7.66 ± 0.27	6.82 ± 0.35	1 vs. 3 (0.029)
TC/HDL	4.54 ± 0.09	4.81 ± 1.2	4.39 ± 0.07	1, 2 vs. 3 (0.050, 0.001)
HDL (mmol/L)	1.32 ± 0.025	1.31 ± 0.017	1.42 ± 0.031	1, 2 vs. 3 (0.015, 0.002)
LDL (mmol/L)	3.71 ± 0.07	3.87 ± 0.06	3.58 ± 0.08	2 vs. 3 (0.013)
SOsteopn	36/120 (30.0%)	55/230 (23.9%)	24/132 (18.2%)	1 vs. 3 (0.020)
HOsteopn	58/120 (48.3%)	96/228 (42.1%)	44/132 (33.3%)	1 vs. 3 (0.011)
Mast	33/121 (27.350%)	69/227 (30.450%)	53/129 (41.1%)	1, 2 vs. 3 (0.021, 0.002)

The parametric measures are presented as ± SE. METmin: Exercise intensity; RT: Retention time of the perceptual capacity test; Grip: Handgrip strength; WBSc: Well-being score; Sbmd: Bone mineral density of the spine at the L2-l4; Hbmd: Bone mineral density of the hip at the femoral neck; TBMC: Total bone mineral content; PLM: Percent lean mass; PBMC: Percent bone mineral content; PBF: Percent body fat; T: Testosterone level; SHBG: Sex hormone binding globulin; INS: Insulin level; TC/HDL: Total cholesterol/HDL ratio; HDL: High density lipoprotein cholesterol; SOsteopn: Osteopenia of the spine at L2-L4; HOsteopn: Osteopenia of the hip at the femoral neck; Mast: Number of persons who engaged in self-masturbation.

physical exercises with most engaging in physical exercises such as casual walking (34.5%) and dancing, Tai Chi, Qigong and swimming (27.6%).

In men, the reaction time (RT) of the perceptual capacity test was faster in both exercise groups (METGp2 & METGp3) by 4.4% to 4.7% (Table 2). In women, on the other hand, the RT was faster only in moderately intense exercise group (METGp2) by 3.6% when compared to those in METGp1 (Table 1). Physical exercise was not associated with any significant difference in the cognitive domain of short-term memory and the error component of the perceptual capacity.

Handgrip strength in men, but not in women was significantly higher, by 4.5%, in the most intense exercise group (METGp3) when compared to the corresponding values in the non-exercise groups (METGp1) (Table 1 and Table 2). Likewise, only in men the sense of well-being was better in the high intensity exercise group (METGp3), with 23.1% less of unwell symptoms when compared to those persons who did not have a regular exercise regime (Table 2).

Only in men both Sbmd and Hbmd were significantly higher in the high intensity group (METGp3) than corresponding values in the group METGp1, with increases of 8.9% and 9.2%, respectively (Table 2). Likewise, total bone mineral content (TBMC) and percent bone mineral content (PBMC) were significantly higher, by 4.2% and 0.14% respectively, in the METGp3 when compared to corresponding values in METGp1 and METGp2 (Table 2). All parameters of bone status in women were not changed whether women were or were not exercising regularly (Table 1).

The present study showed that the incidence of spinal osteoporosis in men and women was 2.5% and 2.9%, respectively. Osteopenia of the spine, on the other hand, was much higher, being 23.9% and 27.1% in men and women, respectively. The incidence of hip osteoporosis and osteopenia were much higher than in the spine. The incidence of hip osteoporosis and osteopenia in men were 8.5% and 41.3% respectively; and in women, 12.5% and 52.4%, respectively. Engagement in high exercise intensity (METGp3) was associated with lower incidence of spinal osteoporosis in women when compared to those in METGp1 (Table 1). In men, on the other hand, high exercise intensity (METGp3) was associated with lower incidence of spinal osteopenia and hip osteopenia (Table 2).

In both men and women, the percent lean mass (PLM) were significantly higher, by 1.9% and 1.8%, respectively in METGp3 when compared to corresponding values in METGp1 (Table 1 and Table 2). In addition, in both men and women, the percent body fat (PBF) in METGp3 was significantly lower by 2.0% and 1.9% respectively, when compared to their corresponding values in METGp1 and METGp2 (Table 2). However, the incidence of general obesity and abdominal obesity were not significantly different whether the individuals had regular physical exercise or not.

Regional distributions of lean and fat mass in men were not affected by participation in exercise, but in women the lean mass in the legs (LegL) was significantly higher, by 2.8% in METGp3 than in METGp1 (Table 1 and Table 2). The distributions of lean and fat mass in other regional areas of the trunk, abdomen, arms and legs were not significantly associated with engagement in physical exercises.

Physical exercise was not associated with changes in levels of most analysed hormonal parameters including Bio-T, IGF-1, IGFBP3, cortisol, TSH and in levels of some metabolic parameters including TC, TG, and glucose. On the other hand, the number of women with insulin resistance index of HOMA indicative of insulin resistance in the highest exercise intensity group, METGp3 was significantly smaller than corresponding levels of women in the METGp1 (Table 1). In men, on the other hand, several factors were clearly associated with exercise of different intensities (Table 2). Interestingly, testosterone was significantly higher by 7.3%, SHBG by 14.6% and HDL, by 7.6% in the highest exercise intensity group (METGp3) when compared to METGp2 (Table 2). On the other hand, insulin level was significantly lower by 13.9%, the TC/HDL ratio, by 3.3% and LDL, by 3.5% (Table 2). Despite the observations that some of the metabolic and cardiovascular biomarkers were positively associated with engagement in intense physical exercise, the same cannot be said about the incidence of metabolic syndrome (MetS) in both men and women.

Of all the lifestyle factors evaluated, women in the moderately high exercise intensity group (METGp2) were significantly more engaged in sex (4.41 time per month) than women in the non-exercise group METGp1) (3.7 times per month) (Table 1). More men in the high exercise intensity group (METGp3), on the other hand, were engaged in masturbation than men in the non-exercise (METGp1) and moderate intensity (METGp2) groups (Table 2). In addition, fewer men in the METGp2 and METGp3 groups had trouble falling asleep than men in the non-exercise group METGp1 (Table 2).

Discussion

Physical exercise as a lifestyle habit was common both in men and women (71.4% and 66.7%, respectively). Noticeably, more men (25.8%) than women (9.3%) were engaged in high intensity of physical exercise as a lifestyle habit. In addition, more men and women who engaged in regular and high intensity of physical exercise were older than those with less intense physical exercise. More men (85%) and women (65%) above 60 y of the Singaporean cohorts were having regular physical exercises. This observation is possibly specific to the cohort of Singaporean men and women and contrasts with Caucasian groups that recorded that only 36% to 45% older people tended to exercise less and less intensely [24-26].

The MET-min was used as an index of intensity of various physical exercises. However, it must be noted that MET-min as an index of the intensity of physical exercise has several limitations. Firstly, the assignment of MET score to the different exercise types is arbitrarily; for example, an assignment 5 MET to brisk walking may not be representative of the various brisk walking speeds. Likewise, a person who plays soccer may not be exerting constant exercise intensity throughout the course of the game. Hence, the computation of the total MET-min for an episode of physical exercise, at best, is an approximation and must be noted as such. Secondly, MET is more representative of the aerobic component of the physical exercise. It is reasonable to assume that every physical exercise, besides an aerobic, has a weight-bearing component, with some exercise types having more of a weight-bearing component than others. For example, the weight-bearing component in jogging is probably more than in swimming. Furthermore, the weight-bearing component is likely to be gender-dependent. The weight-bearing component for jogging in man with higher body weight is likely to be higher than for jogging in a woman with lower body weight. Furthermore, weight lifting has a more dominant weight-bearing component and a small aerobic component. Assignment of a MET-min to weight lifting is thus very arbitrary. Therefore, in general, MET-min is a good index for the aerobic component but not necessarily an accurate index of the weight-bearing component of the physical exercise. The challenge for future studies is to establish more appropriate indices both for the aerobic and weight-bearing components of various physical exercises.

Despite these limitations of MET-min as an index of exercise intensity, the present study, involving a large number of men and women, clearly shows that different physical exercise as a lifestyle habit and when engaged in sufficiently high intensity impart beneficial effects on multiple health compartments [24]. The health benefits include cognitive, bone, cardiovascular, metabolic, sexual, and general health, and improvement of muscular and hormonal functions. In general, the health benefits similarly as in study of Bauman, et al. [27] were associated with physical exercise of high intensity, greater than 1250 MET-min, instead of less than 1000 MET-min noted by the World Health Organization [28]. In addition, physical exercise-associated benefits, in some cases, were gender-specific.

In both men and women, the reaction time in the conceptual capacity cognitive function was faster in those who had moderate to high intensity physical exercise as compared to those without regular physical exercise. However, no change in short-term memory was associated with physical exercise. Since only the perceptual capacity and short-term memory cognitive function tests were evaluated in the present study, extrapolation of the results to other cognitive domains is not appropriate and certainly the results cannot be used to support the conclusion of an earlier study that suggested that regular physical exercise may improve cognitive functions and increase brain plasticity [29].

Clearly, bone status in both men and women benefited from engagement in regular physical exercise of sufficiently high intensity. The benefits in men were indicated by increases in Sbmd, Hbmd, TBMC, PBMC, as well as lower incidences of osteopenia in the spine and hip. In women, however, the bone health benefits of regular physical exercise were indicated by the decreases in the incidence of spine and hip osteoporosis as well as hip osteopenia. Although increases of 0.9% to 1.8% of Sbmd, Hbmd and TBMC in women in the highest intensity exercise group were noted, these increases did not reach significant levels. The lack of significant increases in these bone parameters in women may reflect misclassification of the weight-bearing component of the exercise based on MET-min, as shown by the fact that more than 70% of the physical exercises had lower weight-bearing component. However, overall the fact that high intensity of physical exercise was associated with lower incidences of osteoporosis and osteopenia in both men and women clearly shows that physical exercise at adequate level of intensity is beneficial to bone status in both sexes.

High intensity of physical exercise was also associated with higher amount of lean mass in both men and women and higher lean mass in the legs in women. Furthermore, only in men and not in women, the increase in lean mass was associated with increase in handgrip strength. As mentioned earlier, a possible reason for the differences observed in men and women may be that the physical exercises in women had a lower weight-bearing component than those in men. Physical exercise would be beneficial to mitigate the risk of sarcopenia in men and women as they age [30].

Physical exercise was associated with better metabolic and cardiovascular functions in both men and women. High intensity of regular physical exercise was associated with better metabolic and cardiovascular biomarkers such as higher HDL level, lower INS, TC/HDL ratio, and lower insulin resistance (lower insulin and HOMA levels). These results are indicative for actively promoting regular physical exercise as a strategy to improve the metabolic and cardiovascular health in men and women. Moreover, in both men and women, high intensity of physical exercise was associated with significant reduction of total body fat implying that promotion of physical exercise can be an effective modality for reducing the rate of obesity and mitigating the morbidities associated with it.

Interestingly, high and moderate intensity of physical exercise in men was associated with higher testosterone level of about 7.4% when compared to those who did not exercise routinely as it was also reported earlier [10]. Testosterone is a key hormone involves in sexual functions in men. The observations in the present study suggests that regular high intensity of physical exercise can be a non-drug modality to improve testosterone level thereby improving the sexual functions in men. In addition, more men with high intensity of physical exercise were engaged in masturbation than those who did not have a regular physical exercise regime. However, whether higher level of testosterone is a result or the cause of higher intensity of physical exercise in men is unclear. In women, on the other hand, high intensity of physical exercise was associated with higher frequency of coitus. Other lifestyle factors were also affected by physical exercise, as in men, physical exercise was associated with better ability to fall asleep and a better sense of well-being.

Physical inactivity has been attributed as a major risk factor for cardiovascular disease, cancer and diabetes and to a high proportion of death per year worldwide [31]. Despite these statistics, active promotion of physical exercise to mitigate the risk of morbidity and mortality from the major illnesses has been found wanting [32]. The present study clearly shows that engagement of regular physical exercise as a lifestyle habit is beneficial to most of the major health compartments including those of cognition, bone status, muscular, metabolic and cardiovascular functions, sexual health and general wellbeing in men and women, concurring with the report by the World Health Organization [33]. Actively promoting the health benefits of regular physical exercise must be carried out in earnest to help reduce the risk of these major diseases. The use of the MET-min as an arbitrary index for an individual's engagement in physical activity may be helpful in assessing and thereafter, to advise the individuals to engage in adequate amount of physical activity that is health promoting. Individuals and family doctors can use the MET-min to assess whether they or patients are having adequate physical exercise to garner the ensuing health benefits. The MET-min can be a useful tool for advising individuals or patients to achieve the intensity greater than 1250 MET-min, which is required to reap the associated health benefits.

In summary, the present study involving many men and women showed that regular physical exercise of sufficient intensity as a lifestyle habit has definite health benefits. The major health compartments include some domains of cognition, bone status, cardiovascular and metabolic health, especially the reduction of total body fat and decrease in insulin levels. Some aspects of sexual function, general lifestyle factors such as wellbeing, physical tone and strength, as well as sleep hygiene may also benefit from regular physical exercise. Interestingly, testosterone levels in men may be higher due to regular exercises. The results of the present study support the strategy of promoting regular physical exercise to mitigate increases in risks of the major diseases such as diabetes, metabolic and cardiovascular disorders, as well as sexual, bone and muscular dysfunctions. The MET-min is an objective and practical tool to assess an individual's level of exercise intensity and promotion the attainment of at least > 1000 MET-min in order to attain the exercise associated health benefits.

Author's Contributions

This study was designed, conducted and data collected while Professor Victor HH Goh was at the Department of Obstetrics and Gynaecology, National University of Singapore. Professor Goh was involved in the interpretation, drafting of the manuscript and critical revision of the paper for submission.

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Declaration of Interest

The author reports no declaration of interest.

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