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Title: Leisure-Time Physical Activity and All-Cause Mortality : A Systematic Review

Year: 2022

Version: Published version

Leisure-Time Physical Activity and All-Cause Mortality: A Systematic Review

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Abstract

Many scientific studies have been shown the positive effect of physical activity (PA) on reducing morbidity and mortality, whereas physical inactivity is globally one of the leading factors in mortality. Therefore, the purpose was to investigate the relationship between leisure-time physical activity (LTPA) and all-cause mortality among adult population. The data search was performed of 3 electronic databases for the years 2000-2021 February as follows: Google Scholar, PubMed, and ResearchGate. This search was made by using the following terms and operators AND/OR, individually/combination: "physical activity", "physical fitness", "leisure-time physical activity", "all-cause mortality", "risk of death", "mortality". 1220 studies were initially identified, 22 studies were met the inclusion criteria (5 male studies, 2 female studies, 15 both sexes). The results of this systematic review, with total 2568097 participants (aged 20-98 years), showed that any level of PA had health benefits compared to inactivity and sedentary lifestyle. The highest levels of PA had the lowest risk of all-cause mortality. In conclusion, there is an inverse relationship between LTPA and the risk of all-cause mortality, and the harmful effects of physical inactivity may be largely eliminated among those who are most active. So, promoting regular LTPA is strongly associated with well-being, quality of life and reduced the risk of all-cause mortality both in general adult population and elderly population with chronic diseases.

Keywords: all-cause mortality, LTPA, physical inactity, physical fitness, risk of death.

Introduction

There is a widespread public health policy consensus and scientific evidence based on cohort studies that leisure-time physical activity (LTPA) has a positive effect on health (Holtermann et al., 2012) and LTPA is associated with reduced all-cause and cardiovascular mortality (Arem et al., 2015; Bjelica et al., 2020; Crespo et al., 2002; Hu et al., 2004; Hupin et al., 2015; Woodcock et al., 2011). Physical activity (PA) affects positively health (Boreham & Riddoch, 2001; Martínez-Gómez et al., 2015; Park et al., 2009) because being physically active reduces the risk of morbidity and many diseases associated with poorer mental, physical and social health (N. C. Barengo et al., 2017; de Oliveira et al., 2018; Higueras-Fresnillo et al., 2017). To reduce the risk of premature mortality, it is recommended that individuals perform 30 minutes or more of moderate to vigorous exercise daily or most of the days per week, and to achieve greater health benefits PA should have a longer duration, higher intensity, or greater frequency (Physical Activity Guidelines Advisory Committee, 2008; Warburton et al., 2010).

Previous findings are line with systematic reviews and meta-analyses (Ekelund et al., 2016; Hupin et al., 2015; I. M. Lee et al., 2012; Samitz et al., 2011). It has been found that there was clear evidence of an inverse dose-response relationship between PA volume, fitness level, and all-cause mortality rates (I. Lee, 2001). Additionally, it was observed that the risk of mortality during a given follow-up period continued to decrease with increasing PA levels. It was also suggested that further research was needed to clarify the associations between the dose-response relation between PA and all-cause mortality (I. Lee, 2001). Therefore, it was determined the association with all-cause mortality of different domains of PA (Samitz et al., 2011). It was concluded that higher levels of total and domain-specific PA were associated with reduced all-cause

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mortality, and the risk reduction was largest in vigorous PA (Samitz et al., 2011). Furthermore, it has been found that high levels of moderate-intensity PA eliminated the increased risk of mortality associated with sedentary lifestyle (Ekelund et al., 2016).

Physical inactivity is a major problem globally (World Health Organization, 2009, 2018). World Health Organization (2009) has identified physical inactivity as the fourth leading risk factor for global mortality, 6% of deaths worldwide (World Health Organization, 2009). It has been estimated that insufficient PA contributes to 69.3 million disability-adjusted life-years and 3.2 million deaths each year. Furthermore, it has been reported that almost every third adult is physically inactive and, thus, physical inactivity contributes a major risk factor for non-communicable diseases (I. M. Lee et al., 2012) such as overweight and obesity causes 5% of global mortality.

Therefore, especially now in a Corona-changing world it is important to prioritize PA in health promotion and further strengthen scientific research to highlight the significance and the health benefits of PA. The prevention is the keyword and scientific studies have been shown that PA plays a significant role in preventing and managing diseases, improving quality of life, and decreasing the risk of premature mortality. So, the overall aim of this systematic review was to investigate the relationship between LTPA and all-cause mortality, especially expand the already known conclusions and may provide new information. Firstly, it was examined, how LTPA affects the risk of all-cause mortality. Secondly, it was investigated, which level of LTPA was best for health benefits both in general population and elderly population with chronic diseases.

Methods

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines (Moher et al., 2009).

Search strategy and study selection

The data search was performed of 3 electronic databases for the years 2000-2021 February as follows: Google Scholar, PubMed, and ResearchGate. This search was made by using the following terms and operators AND/OR, individually or in combination: *all-cause mortality, LTPA, physical inactity, physical fitness, risk of death.* The study selection was made by using inclusion and exclusion criteria. English was used as a language restriction and only the free full-text versions of original scientific studies in electronically available Journals were accepted for further analysis. Furthermore, the reference lists of relevant study reports were searched to obtain more studies related to this research topic.

Firstly, to identify relevant study reports, all titles and abstracts were initially reviewed by the authors to exclude titles that were not relevant. So, 1220 potentially acceptable study reports were identified in this initial review. Secondly, 1220 studies were initially screened and retrieved for detailed evaluation. Thirdly, those 22 studies which met the inclusion criteria, were reviewed by the authors in order to make a final decision on inclusion in this systematic review. The study selection process is shown in Figure 1.

Inclusion / exclusion criteria

For the selection of studies, which were included in the final analysis, the following criteria for inclusion were defined: (1) original scientific studies; (2) prospective cohort studies involving those over 18 years of age; (3) a minimum study follow-up time of 4 years; (4) a minimum of 500 participants, who completed the leisure time physical activity (LTPA) questionnaire, included in the study; (5) studies performed LTPA; (6) studies that resulted in all-cause mortality; (7) a minimum of three PA levels (low, moderate, high); (8) studies with available data on the hazard ratio (HR-hazard ratio) or relative risk (RR-relative risk) with a 95% confidence interval (CI); (9) study reported in English.

Based on the following criteria, studies were excluded from further analysis: (1) studies involving those under age of 18 years; (2) study follow-up time less than 4 years; (3) a small number of participants (less than 500); (4) studies that included another type of PA than LTPA; (5) less than three PA levels; (6) studies without available data on HR or RR with 95% CI.

Data extraction and quality assessment

Authors independently extracted the data of the included studies. The data is shown in Table 1. as follows: (1) characteristics of the study, including the first author and year of publication, (2) information on participants such as sample size, gender, age (range or mean), (3) place of study and follow-up time (years), (4) method of PA assessment, (5) assessment of LTPA (number of groups), number of participants and deaths by groups, sexes and total number of deaths. The results of the studies are shown in Table 2. The quality assessment was based on among all whether the cohort had been selected randomly, whether or not the study was based on representative cohort, and whether characteristics of participants was clearly described.

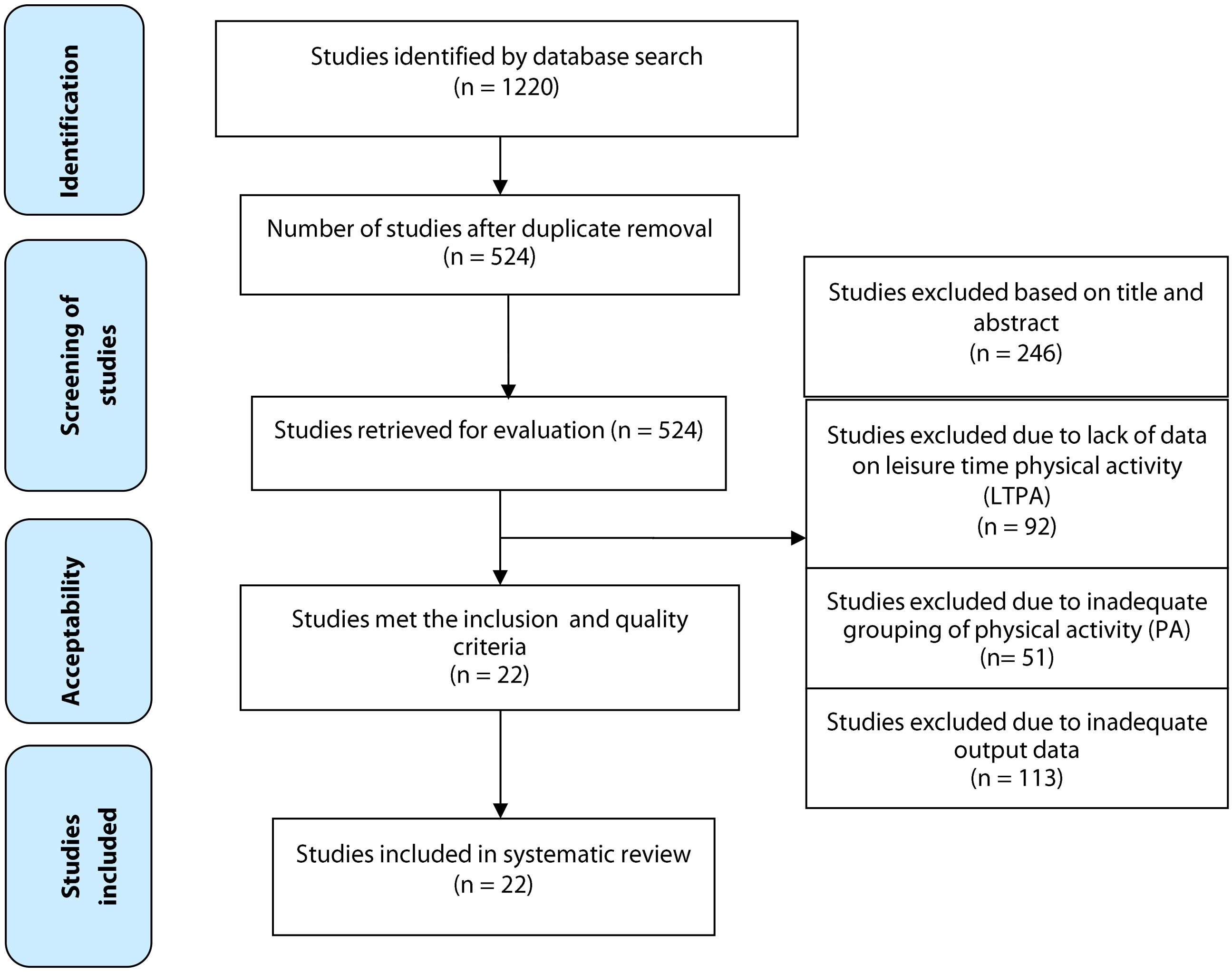

Figure 1. Selection of studies for systematic review.

Results

Study selection

By searching 3 electronic databases, a total of 1220 relevant studies were identified. After removing the duplicates, 524 studies remained. Based on the review of titles and abstracts, 246 studies were excluded, due to lack of data on LTPA 92 studies, 51 studies based on inadequate grouping of PA and 113 due to inadequate output data. According to clearly defined inclusion criteria, 22 studies met the inclusion criteria included in the systematic review and further analysis. Most of the selected studies were original prospective cohort studies, but also a couple of studies (Arem et al., 2015; Liu et al., 2018; Moore et al., 2012) based on consortium of cohorts (including 6, 6 and 9 study cohorts) were included in the systematic review because they pooled large quantity of data on national cohorts. However, all the selected studies (n=22) were considered as primary sources (original study reports) because secondary sources (e.g. reviews) could not be extracted in the systematic review.

Study characteristics

All studies (n=22) included in the systematic review were published in English by February 2021. The longest follow-up time of the study was 35 (Byberg et al., 2009), and the shortest 4.1 years (Schooling et al., 2006). The total sample size was 2568097 participants, of which 1133006 males and 1435091 females. Five studies included only males (Byberg et al., 2009; Holtermann et al., 2009; Holtermann et al., 2012; Park et al., 2009; Savela et al., 2010; Ueshima et al., 2010), two studies included females (Carlsson et al., 2006; Rockhill et al., 2001; Woodcock et al., 2011), while 15 studies included both sexes (Andersen et al., 2000; Arem et al., 2015; Autenrieth et al., 2011; Hu et al., 2004; Hu et al., 2005; Khaw et al., 2006; Lahti et al., 2014; Liu et al., 2018; Moore et al., 2012; Sabia et al., 2012; Schnohr et al., 2003; Schooling et al., 2006; Wen et al., 2011; Zhao et al., 2014). The highest number of participants was 661137 (Arem et al., 2015) and the lowest 782 (Savela et al., 2010). The age of the participants ranged from 20 to 98 years. Total number of deaths during the follow-up period in different studies varied from 267 (M= 193, F= 74) to 82465 (M= 51172, F= 31293) at the any level of PA (Table 1).

Table 1

Basic characteristics and parameters of the studies.

First author and year	Gender and age (range)	Study and follow-up time (years)	PA assessment	Categorized groups related to leisure time physical activity (LTPA) (n), number of deaths (n1,n2)
(Andersen et al., 2000)	N = 27892 M = 14776 F = 13116 20-93	The Copenhagen City Heart Study, The Glostrup Population Studies, The Copenhagen Male Study, 14.5	Self-report questionnaire PA	Inactivity: M (n = 3024, n1 = 1190) F (n = 3235, n1 = 919) (n = 6259, n1 = 2109) Low: M (n = 7909, n1 = 2448) F (n = 7437, n1 = 1413) (n = 15346, n1 = 3861) Moderate: M (n = 3506, n1 = 980) F (n = 2350, n1 = 396) (n = 5856, n1 = 1376) High: M (n = 337, n1 = 54) F (n = 94, n1 = 10) (n = 431, n1 = 64) n2 = 7410 (M n2 = 4672, F n2 = 2738)
(Haapanen-Niemi et al., 2000)	N = 2068 M = 1038 F = 1030 40-63	A regionally representative cohort of Finnish men and women, 16	Self-report questionnaire PA	Low: M (n = 322, n1 = 86) F (n = 310, n1 = 40) (n = 632, n1 = 126) Moderate: M (n = 369, n1 = 57) F (n = 392, n1 = 17) (n = 761, n1 = 74) High: M (n = 347, n1 = 50) F (n = 328, n1 = 17) (n = 675, n1 = 67) n2 = 267 (M n2 = 193, F n2 = 74)
(Rockhill et al., 2001)	N = 80348 F = 80348 30-55	The Nurses' Health Study, 16	Self-report questionnaire PA	<1.0 (h / w) (n = 20568, n1 = 1333) 1.0-1.9 (n = 23071, n1 = 1203) 2.0-3.9 (n = 13499, n1 = 1204) 4.0-6.9 (n = 13475, n1 = 790) ≥7.0 (n = 9735, n1 = 216) n2 = 4746

First author and year	Gender and age (range)	Study and follow-up time (years)	PA assessment	Categorized groups related to leisure time physical activity (LTPA) (n), number of deaths (n1,n2)
(Schnohr et al., 2003)	N = 7023 M = 3220 F = 3803 20-79	The Copenhagen City Heart Study, 17-19	Self-report questionnaire PA	Low: M (n = 550, n1 = 280) F (n = 602, n1 = 264) (n = 1152, n1 = 544) Moderate: M (n = 1603, n1 = 737) F (n = 2328, n1 = 751) (n = 3931, n1 = 1488) High: M (n = 1067, n1 = 407) F (n = 873, n1 = 286) (n = 1940, n1 = 693) n2 = 2725 (M n2 = 1424, F n2 = 1301)
(N. l. C. Barengo et al., 2004)	N = 32677 M = 15853 F = 16824 30-59	North Karelia Project, FINMONICA / Finrisk studies, 20	Self-report questionnaire PA and clinical examination	Low: M (n = 4372, n1 = 1184) F (n = 6212, n1 = 907) (n = 10584, n1 = 2091) Moderate: M (n = 8337, n1 = 1853) F (n = 8387, n1 = 783) (n = 16724, n1 = 2636) High: M (n = 3144, n1 = 373) F (n = 2225, n1 = 172) (n = 5369, n1 = 545) n2 = 5272 (M n2 = 3410, F n2 = 1862)
(Hu et al., 2004)	N = 47212 M = 22528 F = 24684 25-64	Six independent cross-sectional population (Oulu, Kuopio and North Karelia provinces, Turku-Loimaa region, Helsinki) 17.7	Self-report questionnaire PA	Low: M (n = 2132, n1 = 642) F (n = 3613, n1 = 739) (n = 5745, n1 = 1381) Moderate: M (n = 9659, n1 = 2095) F (n = 11782, n1 = 1337) (n = 21441, n1 = 3432) High: M (n = 10737, n1 = 1826) F (n = 9289, n1 = 755) (n = 20026, n1 = 2581) n2 = 7394 (M n2 = 4563, F n2 = 2831)
(Carlsson et al., 2006)	N = 27374 F = 27374 51-83	The Swedish Mammography cohort, 5	Self-report questionnaire PA	<1 h/w, n1 = 395 1, n1 = 242 2-3, n1 = 352 4-5, n1 = 120 > 5, n1 = 123 n2 = 1232

First author and year	Gender and age (range)	Study and follow-up time (years)	PA assessment	Categorized groups related to leisure time physical activity (LTPA) (n), number of deaths (n1,n2)
(Khaw et al., 2006)	N = 22191 M = 9984 F = 12207 45-79	EPICNorfolk (European Prospective Investigation into Cancer and Nutrition) a prospective population study, 8	Self-report questionnaire PA	Inactive: M (n = 2828); F (n = 3463) (n = 6291) Moderately inactive: M (n = 2532) F (n = 3997) (n = 6529) Moderately active: M (n = 2320) F (n = 2767) (n = 5087) Active: M (n = 2304) F (n = 1980) (n = 4284) n2 = 1553 (M n2 = 930, F n2 = 623)
(Schooling et al., 2006)	N = 54088 M = 18126 F = 35962 ≥65	Hong Kong, China, 4.1	Self-report questionnaire PA and clinical examination	Inactive: M (n = 3044) F (n = 5177) ≥30 (minutes per day): M (n = 6100) F (n = 12990) >30: M (n = 8982) F (n = 17795) n2 = 3819
(Byberg et al., 2009)	N = 2205 M = 2205 49-51	Sweden, Uppsala longitudinal study of adult men (ULSAM), 35	Self-report questionnaire PA created in collaboration with the Swedish National Institute of Public Health	Low: n = 325 n1 = 198 Moderate: n = 802 n1 = 600 High: n = 1078 n1 = 531 n2 = 1329
(Holtermann et al., 2012)	N = 4832 M = 4832 40-59	The Copenhagen Male Study, 30	Questionnaire (e.g. PA), short interview, clinical examination (height, weight, blood pressure)	Low: n = 814 n1 = 526 Moderate: n = 3514 n1 = 1845 High: n = 504 n1 = 218 n2 = 2589
(Park et al., 2009)	N = 18775 M = 18775 55.7	Health Promotion Center at Seoul National University Hospital, 6.4	Self-report questionnaire PA	Regular(30min x 3 times a week): Low: n = 2541 Moderate: n = 2114 High: n = 2502 Irregular: Low: n = 4246 Moderate: n = 3085 High: n = 3639
(Savela et al., 2010)	N = 782 M = 782 47.8	Institute of Occupational Health in Helsinki, Finland, 34	Self-report questionnaire PA, clinical and laboratory examination	Low: n = 148 n1 = 66 Moderate: n = 398 n1 = 142 High: n = 236 n1 = 74 n2 = 282
(Ueshima et al., 2010)	N = 11671 M = 11671 65-84	The Shizuoka Study, Japan, 6	Self-report questionnaire PA, how many days a week do they spend 30 minutes or more LTPA	Low: n = 5671 n1 = 194 Medium low: n = 2212 n1 = 175 Moderate: n = 1623 n1 = 190 High: n = 2165 n1 = 440 n2 = 999

First author and year	Gender and age (range)	Study and follow-up time (years)	PA assessment	Categorized groups related to leisure time physical activity (LTPA) (n), number of deaths (n1,n2)
(Autenrieth et al., 2011)	N = 4672 M = 2373 F = 2299 25-74	Cooperative Health Research in the Region of Augsburg (KORA), 17.8	Questionnaire MONICA Optional Study on Physical Activity (MOSPA)	Inactivity: n = 466 n1 = 137 Low: n = 1918 n1 = 406 Moderate: n = 1533 n1 = 374 High: n = 755 n1 = 78 n2 = 955
(Wen et al., 2011)	N = 416175 M = 199265 F = 216910 40-63	Prospective cohort study, MJ Health Management Institution, Taipei, Taiwan 13	Self-report questionnaire PA, information on medical history and lifestyle.	Inactive: M (n = 96798) F (n = 129695) (n = 226493, n1 = 5688) Low: M (n = 44246) F (n = 46417) (n = 90663, n1 = 1877) Moderate: M (n = 31593) F (n = 25306) (n = 56899, n1 = 1660) High: M (n = 13184) F (n = 8546) (n = 21730, n1 = 742) Very high: M (n = 13444) F (n = 6946) (n = 20390, n1 = 813) n2 = 10780
(Moore et al., 2012)	N = 654827 M = 290136 F = 364691 21-90	The National Institutes of Health (NIH) –AARP Diet and Health Study, The Cancer Prevention Study II Nutrition Cohort (CPS II), CLUE IIWashington County, The US Radiologic Technologists study, The Women's Health Study, The Women's Lifestyle and Health, 10	Self-report questionnaire PA	0 METs M (n1 = 5767) F (n1 = 3987) (n = 50555, n1 = 9754) 0.1-3.74 M (n1 = 10975) F (n1 = 7377) (n = 112661, n1 = 18352) 3.75-7.4 M (n1 = 4241) F (n1 = 2727) (n = 60132, n1 = 6968) 7.5-14.9 M (n1 = 12713) F (n1 = 7715) (n = 167931, n1 = 20428) 15.0-22.4 M (n1 = 7443) F (n1 = 4371) (n = 118255, n1 = 11814) ≥22.5 M (n1 = 10033) F (n1 = 5116) (n = 145293, n1 = 15149) n2 = 82465 (M n2 = 51172, F n2 = 31293)

First author and year	Gender and age (range)	Study and follow-up time (years)	PA assessment	Categorized groups related to leisure time physical activity (LTPA) (n), number of deaths (n1,n2)
(Sabia et al., 2012)	N = 7456 M = 5213 F = 2243 35-55	Whitehall II Study, 9.6	Self-report questionnaire on lifestyle factors and clinical examination (e.g. PA)	Low: M (n = 1791) F (n = 624); (n = 2415, n1 = 105) Moderate: M (n = 1646) F (n = 715); (n = 2361, n1 = 100) High: M (n = 1776) F (n = 904); (n = 2680, n1 = 112) n2 = 317
(Lahti et al., 2014)	N = 6429 M = 1378 F = 5051 40-60	Helsinki Health Study, 12	Self-report questionnaire PA	Low moderate: M (n = 118, n1 = 13) F (n = 414, n1 = 19) (n = 532, n1 = 32) Highly moderate: M (n = 579, n1 = 41) F (n = 2964, n1 = 81) (n = 3543, n1 = 122) High: M (n = 681, n1 = 18) F (n = 1673, n1 = 33) (n = 2354, n1 = 51) n2 = 205 (M n2 = 72, F n2 = 133)
(Zhao et al., 2014)	N = 10535 M = 5431 F = 5104 46 average	National Health and Nutrition Examination Survey (NHANES), 4.8	Self-report questionnaire PA	Inactive: n = 4604 n1 = 436 Insufficiently active: n = 2254 n1 = 99 Active: n = 3677 n1 = 130 n2 = 665
(Arem et al., 2015)	N = 661137 M = 291485 F = 369652 21-98	National Cancer Institute Cohort Consortium (included 6 cohorts), 14.2	Self-report questionnaire PA	0 METs (n = 52848, n1 = 11523) 0.1<7.5 (n = 172203, n1 = 33511) 7.5<15.0 (n = 170563, n1 = 28957) 15.0<22.5 (n = 118169, n1 = 19979) 22.5<40.0 (n = 124446, n1 = 21114) 40.0<75.0 (n = 18831, n1 = 1390) ≥75.0 (n = 4077, n1 = 212) n2 = 4746
(Liu et al., 2018)	N = 467729 M = 213935 F = 253794 47.6-59.9	Asia Cohort Consortium (ACC), (included 9 cohorts), 13.6	Self-report questionnaire PA	Inactive: (n = 332829, n1 = 45963) Low: (n = 51578, n1 = 6940) Moderate: (n = 32554, n1 = 4625) High: (n = 50768, n1 = 8330) n2 = 65858

*Physical activity (PA), N total number of participants, M male, F female,n subgroup, n1 number of deaths, n2 total number of deaths.

Study results

The results of the selected studies are shown in Tables 1. (e.g. number of deaths) and 2. (e.g. Hazard Ratios-HR, relative risk-RR). Based on the PA self-report questionnaire in leisure-time (LTPA questionnaire), groups related to PA (e.g. inactive, low active, moderate active, highly active) were defined according to the participants` answers. In 12 studies reported PA was classified into three categories (low, moderate and high), which was based on energy consumption (<3, 3-5.9 and ≥6 METs) (N. l. C. Barengo et al., 2004; Holtermann et al., 2009; Hu et al., 2005; Lahti et al., 2014; Savela et al., 2010; Schnohr et al., 2003; Zhao et al., 2014).

Most of the studies reported an inverse relationship between the level of LTPA and the risk of all-cause mortality (e.g. Andersen et al. (2000); N. l. C. Barengo et al. (2004); Carlsson et al. (2006); Khaw et al. (2006); Lahti et al. (2014); I. M. Lee et al. (2012); Moore et al. (2012); Ueshima et al. (2010); Wen et al. (2011); Zhao et al. (2014)). Byberg et al., 2009 reported that all-cause mortality rate was the lowest in the high (reference) level of PA compared to moderate (HR 1.24, 95% CI 1.10-1.39) and low level (HR 1.41, 95% CI 1.19-1.67). Schnohr et al. (2003) found that moderate and high levels of PA in men (RR 0.71, 95% CI 0.57-0.88; p = .002; RR 0.61, 95% CI 0.48-0.76, p <.001) and women (RR 0.64, 95% CI 0.52-0.79, p <.001; RR 0.66, 95% CI 0.51-0.85, p = .001) had the lowest risk of mortality. Findings was based on the categorization PA into low (<4METs), moderate (4-6 METs) and high (> 6 METs) (Schnohr et al., 2003). However, Sabia et al. (2012) observed that moderate level of PA (HR 0.48, 95% CI 0.38-0.63) had lower mortality rate compared to high (HR 0.62, 95% CI 0.45-0.86) and low (HR 1.00) level of PA.

Four studies Andersen et al. (2000); Autenrieth et al. (2011); Khaw et al. (2006); Ueshima et al. (2010) categorized PA into four groups, and the results indicated that the highest level of PA had the lowest mortality rate. Autenrieth et al., 2001 observed that, the group defined as vigorous PA (> 6.0 METs), reduced the risk of all-cause mortality by 27% (HR 0.48 95% CI 0.36-0.65) compared to sitting (inactive, 0 METs) by 52%. Liu et al., 2018 had consortium of 9 cohorts, and they found that there was a reduced risk of all-cause mortality in each reported PA group (inactive <1.0; low 1.0-2.9; moderate 3.0-4.9; high ≥5 hours per week) compared to the inactive one.

Three studies Carlsson et al. (2006); Rockhill et al. (2001); Wen et al. (2011) were classified PA into five groups. Rockhill et al., 2001 found that each level of PA above the reference (<1.0 hour per week PA) had approximately the same level of risk reduction (20% -30%). Carlsson et al., 2006 observed that the reference group had the highest duration of PA (>5 hours per week) and an increased risk of all-cause mortality was observed in less physically active groups (RR 1.09, 95% CI 0.88–1.36 for 1 hour per week; RR 1.02, 95% CI 0.83 – 1.26 for 2-3; RR 0.95, 95% CI 0.74–1.22 for 4-5 hours per week).

Moore et al., 2012 had consortium of six cohorts, and they categorized PA into six groups which was based on energy consumption (METs). It was found that higher levels of LTPA were associated with a reduction of the risk of all-cause mortality in both sexes (0 MET; 0.1-3.74 METs; 3.75-7.4 METs; 7.5-14.9 METs; 15.0-22.4; ≥22.5 METs; HR 1.00, HR 0.81 (95% CI 0.79-0.83), HR 0.76 (95% CI 0.74-0.78), HR 0.68 (95% CI 0.66-0.69), HR 0.61 (95% CI 0.59-0.63), HR 0.59 (95% CI 0.57-0.61)). The highest percentage (19.3%) of deaths was clearly reported in the group that did not report PA (0 METs) (Moore et al., 2012).

Arem et al., 2015 had consortium of six cohorts, and they categorized PA into seven groups (inactive 0 MET to highly active ≥75.0 METs). It was observed that there was 20% lower risk of mortality in those with PA at 0.1 <7.5 METs (HR 0.80, 95% CI 0.78-0.82), 31% at 7.5 <15.0 METs (HR 0.69, 95% CI 0.67-0.70), 37% at 15.0 <22.5 METs (HR 0.63, 95% CI 0.62-0.65) and 39% at 22.5 <40.0 METs and 40.0 <75.0 METs (HR 0.61, 95% CI 0.59- 0.62; HR 0.61, 95% CI 0.58-0.64) compared to unreported PA (0 METs).

Table 2

Results of the studies (Cox proportional hazards models: Hazard ratio HR (95% CI), Relative risks RR (95% CI))

First author and year	LTPA	n1	Hazard ratio HR (95% CI) Cox proportional hazards models	Relative risks RR (95% CI) Cox proportional hazards models
(Andersen et al., 2000)	<2 h / w (sedentary or light);	2109		1.00
	2-4 h / w (light);	3861		0.68 (0.64-0.72)
	>4 (light) or 2-4 (high);	1376		0.64 (0.60-0.66)
	>4 (high/vigorous).	64		0.53 (0.42-0.69)

First author and year	LTPA	n1	Hazard ratio HR (95% CI) Cox proportional hazards models	Relative risks RR (95% CI) Cox proportional hazards models
Naapanen-Niemi et al., 2000	M: 0-1000; F: 0-800; 1000.1-1900; 800.1-1500; > 1900 kcal/w. > 1500 kcal/w	126 77 67		M: 1.20 (0.82-1.76) F: 1.27 (0.69-2.34) 0.82 (0.55-1.24) 0.59 (0.30-1.18) 1.00 1.00
(Rockhill et al., 2001)	<1.0; 1.0-1.9; 2.0-3.9; 4.0-6.9; ≥7.0 h/w.	1333 120 120 790 216		1.0 0.82 (0.76, 0.89) 0.75 (0.69, 0.81) 0.74 (0.68, 0.81) 0.71 (0.61, 0.82)
(Schnohr et al., 2003)	<4; 4-6; > 6 METs.	544 1488 693		M: 1.00 F: 1.00 0.71 (0.57-0.88) 0.64 (0.52-0.79) 0.61 (0.48-0.76) 0.66 (0.51-0.85)
(N. l. C. Barengo et al., 2004)	Watching TV, reading; 0-4 h/w (light): > 3 h/w (intensive, recreational sport).	2091 2363 545	M: 1.00 0.91 (0.84-0.98) 0.79 (0.70-0.90) F: 1.00 0.89 (0.81–0.98) 0.98 (0.83–1.16)	
(Hu et al., 2004)	Watching TV, reading; Walking, gardening; Running, swimming.	1381 3432 2581	M: 1.00 F: 1.00 0.64 (0.59–0.70) 0.59 (0.54–0.65) 0.53 (0.49-0.58) 0.52 (0.47-0.57)	
(Carlsson et al., 2006)	<1; 1; 2-3; 4-5, > 5 h/w.	395 242 352 120 123		1.91 (1.56-2.35) 1.09 (0.88-1.36) 1.02 (0.83-1.26) 0.95 (0.74–1.22) 1.00
(Khaw et al., 2006)	0; <0.5; 0.5-1; > 1 h/d.	1553		1.00 0.83 (0.73-0.95) 0.68 (0.58-0.80) 0.68 (0.57-0.81)
(Schooling et al., 2006)	0; ≥30; >30 min/d.	3819	1.00 0.83 (0.76-0.91) 0.73 (0.67-0.80)	
(Byberg et al., 2009)	Low; Moderate; High.	198 600 531	1.41 (1.19-1.67) 1.24 (1.10-1.39) 1.00	
(Holtermann et al., 2009)	Low; Moderate; High.	526 1845 218	1.00 0.74 0.67–0.82 0.62 0.53–0.72	
(Park et al., 2009)	Regular (30 min x 3 times a week): Low; Moderate; High.	547	1.00 0.58 (0.47-0.70) 0.58 (0.45-0.75)	

First author and year	LTPA	n1	Hazard ratio HR (95% CI) Cox proportional hazards models	Relative risks RR (95% CI) Cox proportional hazards models
(Savela et al., 2010)	Low;	66	1.64 (1.15-2.34)	
	Moderate;	142	1.22 (0.90-1.64)	
	High.	74	1.0	
(Ueshima et al., 2010)	<30 min/d	194	1.00	
	≥30 1-2 d/w	175	0.67 (0.52, 0.86)	
	≥30 3-4 d/w	190	0.46 (0.36, 0.59)	
	≥30 ≥5 d/w	440	0.39 (0.31, 0.49)	
(Autenrieth et al., 2011)	0;	137	1.00	
	<3.0;	406	0.73 (0.60-0.89)	
	3.0-6.0;	374	0.78 (0.64-0.95)	
	> 6.0 METs.	78	0.48 (0.36-0.65)	
(Wen et al., 2011)	<3.75;	5688	1.00	
	3.75-7.49;	1877	0.86 (0.81-0.91)	
	7.50-16.49;	1660	0.80 (0.75-0.85)	
	16.5-25.49;	742	0.71 (0.65-0.77)	
	≥25.5 METs	813	0.65 (0.60-0.70)	
(Moore et al., 2012)	0;	9754	1.00	
	0.1-3.74;	18352	0.81 (0.79-0.83)	
	3.75-7.4;	6968	0.76 (0.74-0.78)	
	7.5-14.9;	20428	0.68 (0.66-0.69)	
	15.0-22.4;	11814	0.61 (0.59-0.63)	
	≥22.5 METs.	15149	0.59 (0.57-0.61)	
(Sabia et al., 2012)	<3	105	1.00	
	3-5.9	100	0.48 (0.38-0.63)	
	≥6 METs.	112	0.62 (0.45-0.86)	
(Lahti et al., 2014)	Walking;	32	1.00	
	Brisk walking;	122	0.73 (0.49–1.11)	
	Running / jogging.	51	0.55 (0.32–0.94)	
(Zhao et al., 2014)	0;	436	1.00	
	> 0 - <150;	99	0.72 (0.54-0.97)	
	≥150 (moderate) or ≥75 min/w (high)	130	0.64 (0.52-0.79)	
(Arem et al., 2015)	0;	11523	1.00	
	0.1 <7.5;	33511	0.80 (0.78-0.82)	
	7.5 <15.0;	28957	0.69 (0.67-0.70)	
	15.0 <22.5;	19979	0.63 (0.62-0.65)	
	22.5 <40.0;	21114	0.61 (0.59-0.62)	
	40.0 <75.0;	1390	0.61 (0.58-0.64)	
	≥75.0 METs.	212	0.69 (0.59-0.78)	
(Liu et al., 2018)	<1.0;	45963	1.00	
	1.0-2.9;	6940	0.85 (0.81-0.90)	
	3.0-4.9;	4625	0.86 (0.81-0.92)	
	≥5 h/w.	8330	0.86 (0.82-0.91)	

*Leisure time physical activity (LTPA), n1 number of deaths per group, h/w hours per week, h/d hours per day, min/d minutes per day, min/w minutes per week, kcal/w kilocalories per week, metabolic equivalent (MET), M male, F female.

Discussion

Our findings

The purpose of this systematic review was to determine how leisure-time physical activity (LTPA) affects the risk of all-cause mortality. The results of the reviewed studies showed that there was an inverse relationship between LTPA and the risk of all-cause mortality. Those who were most physically active had the lowest mortality rate. Also, an increase from minimal to higher levels of LTPA had health benefits and lower risk of mortality, while a decrease from higher levels was associated with higher risk of all-cause mortality. The findings of this systematic review confirmed widespread international PA guidelines, supported the evidence of PA health benefits and the decreased risk of all-cause mortality both general adult population and population with chronic diseases.

This review shows that LTPA has beneficial health effects among general adult population and elderly patients with chronic diseases. Based on the present results of this systematic review and previous studies and international PA Guidelines (Warburton et al., 2010), it is reasonable to suggest for general population and elderly population with chronic diseases being daily physically active at any level PA to improve quality of life, reduce the harmful effects of physical inactivity and decrease the risk of premature mortality. However, it could be noted that the higher level of PA, the lower risk of all-cause mortality. It is important not only to increase the patient's PA level but also to improve other health behaviours (e.g. alcohol use, smoking and diet) in real-life clinical work. Furthermore, individually based factors (e.g. age, fitness level, disease status, personal interests) should be considered when tailoring PA for patient. This study is noteworthy from a viewpoint of individual and public health especially now during and after the COVID-19-pandemia,as it seems that some group among general populations may decrease their PA (Martínez-Gómez et al., 2015; Meyer et al., 2020) while the others, particularly those who exercised before the pandemic and athletic population, increase it or maintained (Brand et al., 2020).

Comparisons with previous systematic reviews and meta-analyses

There is scientific evidence based on systematic reviews and meta-analyses that LTPA has a positive effect on health and is associated with a reduced risk of all-cause mortality (Ekelund et al., 2016; Hupin et al., 2015; I. M. Lee et al., 2012; Samitz et al., 2011). The mortality risk continues to decline with increasing PA levels, rather than showing a threshold, in both sexes, as well as in those younger and older than 60 years (I. M. Lee et al., 2012). It has been previously observed that higher levels of total and domain-specific PA were associated with reduced all-cause mortality, and the risk reduction was largest in vigorous PA (Samitz et al., 2011). This is line with our findings that indicated the highest level of PA had the lowest mortality rate (e.g. Andersen et al. (2000); Autenrieth et al. (2011); Byberg et al. (2009); Carlsson et al. (2006); Khaw et al. (2006); I. Lee (2001); I. M. Lee et al. (2012); Martínez-Gómez et al. (2015); Moore et al. (2012); ZelenovİĆ et al. (2021); Zhao et al. (2014)) and increased risk of all-cause mortality was observed in less physically active groups (I. Lee, 2001). We also found that groups with the lowest duration of LTPA had the highest number of deaths ranging from 19.9% (Haapanen-Niemi et al., 2000) to 64.6% (Holtermann et al., 2009) at any level of PA (low, moderate, high). However, one study observed that moderate level of PA has the lowest mortality rate compared to high level of PA (Sabia et al., 2012), both moderate and high PA levels had the lowest mortality risk (Schnohr et al., 2003).

It was found in our systematic review that there was a reduced risk of all-cause mortality at any level of reported PA group compared to the physically inactive participants (Arem et al., 2015; N. l. C. Barengo et al., 2004; Liu et al., 2018; Martínez-Gómez et al., 2015), the risk of premature mortality was approximate 31% lower among physically active compared to physically inactive participants (N. l. C. Barengo et al., 2004). Furthermore, it was shown that high levels of moderate-intensity PA (60–75 minutes per day) eliminated the increased risk of mortality associated with sedentary lifestyle (Ekelund et al., 2016). Consequently, it was observed that the risk of mortality decreased by 28–36% among individuals who increased their PA from low to the recommended (≥150 minutes per week) (Zhao et al., 2014). Our findings were line with the Hupin et al., 2015 systematic review and meta-analysis, which found that even a low-dose of moderate-to-vigorous PA reduced mortality by 22% among adults aged 60 years.

In summary, the prevention is the keyword especially beyond COVID-19-pandemia and the results of this systematic review and previous studies provided that any level of LTPA reduced the harmful effects of physical inactivity and sedentary lifestyle. However, the all-cause mortality rates were significantly reduced especially at higher levels of LTPA and largely eliminated among those who were most active. This systematic review showed that despite age, sex and nationality promoting regular LTPA was strongly associated with better quality of life and reduced the risk of all-cause mortality both in general adult population and elderly population with chronic diseases.

Strengths and limitations

There were several strengths of this systematic review. Firstly, the study selection process was independently made by more than one researcher and exactly defined inclusion/exclusion criteria (minimized selection bias and increased internal validity). Secondly, the comprehensively reported results (both text and tables) of this study were based on a large study population from different nationalities (e.g. European and Asian cohorts), both sexes, and different ages (both young adults and older population), which was leading to more comprehensive review of the research topic. All the selected studies were original scientific reports and included both basic prospective cohort studies and also a couple of studies (Moore et al., 2012) based on consortium of cohorts (including 6, 6 and 9 study cohorts) were included in the systematic review because they pooled large quantity of data on national cohorts. Thirdly, the relevant data from existing systematic reviews and meta-analyses (Ekelund et al., 2016; Hu et al., 2005; Hupin et al., 2015; I. M. Lee et al., 2012; Samitz et al., 2011) were synthesized and combined in our findings in Discussion.

However, self-reported data on health-related behaviors include known limitations (e.g. overestimation of PA). So, one limitation of this systematic review was that the LTPA was measured by self-report PA questionnaire in included studies. Furthermore, there was the heterogeneity between PA questionnaires, and PA may change throughout life and it might be changed during a given the follow-up period in studies. Also, the range of follow-up period was large, which could lead to misclassification of the levels of PA, especially among the elderly population cohort, and therefore the results might be biased. Additionally, the levels of PA in all studies were not equally classified according to duration, frequency, or intensity. Another limitation relates to the heterogeneity between reporting the results from the different studies (e.g. objective criteria (METs) versus ordinal categories (inactive, moderate active, highly active), and adjusting statistical models with the confounding factors, e.g. and sex, varied). There could be also used a specific quality assessment tool (e.g. STROBE checklist and/or Crowe Critical Appraisal Tool (CCAT)) in this review to reduce the heterogeneity of the studies and further increase the generalizability of the results. Additionally, there might be generally a tendency for publication bias related to this research topic.

Future directions

The recommendation for further research related to LTPA/total PA and mortality would be to conduct a systematic review and meta-analysis to examine a larger number of high-quality prospective cohort studies focusing on the different levels, intensity (light, moderate, vigorous) and specific domains of PA collected by using both the same valid and reliable questionnaire (such as the Minnesota Leisure Time Physical Activity Questionnaire (MLTPAQ)) and objective method (such as accelemeter/pedometer/a double labelled water) in all studies. There is also a possibility to conduct a systematic review and meta-analysis to investigate relationships between diffent levels and domains of PA and mortality among both general and specific populations (such as patients with chronic disease such as type 2 diabetes, heart disease or depression). Furthermore, it could be interesting to investigate associations between COVID-19-pandemia, LTPA/total PA and morbidity or mortality in the future.

Conclusion

Analyzing all the studies included in this systematic review, it was concluded that there is an inverse relationship between LTPA and the risk of all-cause mortality. High levels of LTPA may reduce the risk of all-cause mortality more than low or moderate levels. The percentage of deaths may decrease while LTPA increases, and the harmful effects of physical inactivity may largely eliminate among those who are most active. These findings support scientific evidence of the health benefits of LTPA. So, promoting regular LTPA is strongly associated with well-being, quality of life and reduced the risk of all-cause mortality both in general adult population and elderly population with chronic diseases.

Acknowledgements: No

Conflict of interest: The authors have no conflicts of interest relevant to this article.

Funding: No financial or material support of any kind was received for the work described in this article.

Authorship: All authors have equal rights

Ethical approval

This study was conducted according to good clinical and scientific practice. The authors declare that the results of this study are presented clearly, honestly, and without fabrication, falsification or inappropriate data manipulation.

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