

A Systematic Review of the Relationship Between Physical Activity and Happiness

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Published online: 24 March 2018

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Abstract This study aimed to examine the relationship between physical activity and happiness through systematically reviewing the existing literature. A systematic search of major databases including PubMed/Medline, PsychInfo, SportDiscus, and Embase was performed in 2017 for original research articles published post-1980 with the related keywords of happiness and physical activity. From 1142 retrieved records, fifteen observational studies (thirteen cross-sectional studies and two longitudinal studies) and eight intervention studies (six randomized controlled trials and two non-randomized trials) were included for further analysis. These studies involved a wide range of population from various countries and areas. All the observational studies reported positive associations between physical activity and happiness. As little as 10-min physical activity per week or 1 day of doing exercise per week might result in increased levels of happiness. Mediation effects were examined in two studies indicating the positive relationship between physical activity and happiness might be mediated by health and social functioning. The randomized controlled trials mostly focused on older adults and cancer survivors, and suggested that both aerobic exercise and stretching/balancing exercise were effective in improving happiness. Evidence showed a consistent positive relationship between physical activity and happiness. However, due to the limited number of randomized controlled trials, we cannot draw firm conclusions regarding the causal relationship between physical activity and happiness. Future research is suggested to explore the mechanism of how physical activity influences happiness and to determine the optimal dose and type of physical activity for gaining the benefits of happiness.

Keywords Exercise · Positive psychology · Subjective well-being · Mental health

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1 Introduction

The benefits of physical activity (PA) on mental health have been well documented (Saxena et al. 2005). For instance, there is a large body of literature demonstrating that PA effectively reduces depression and anxiety (Ströhle 2009). However, previous studies have predominantly focused on the effects of PA on the negative aspects of mental health and concerned the use of PA as a preventive or curative approach for mental disorders (Rosenbaum et al. 2014). The investigation of the relationship between PA and mental disorders is of importance because mental disorders are linked to increased morbidity, premature mortality, and greater medical cost (Alexopoulos 2005; Katon et al. 2003). In contrast, the relationship between PA and positive mental constructs has remained largely unexplored. The World Health Organization has stressed the positive dimension of mental health and defined that “health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO 2014). At the beginning of 21st century, Seligman and Csikszentmihalyi (2000) pointed out the psychology’s empirical focus should shift from “only preparing the worst things in life to also building positive qualities”. Therefore, attention should not only be given to the negative aspects when examining the relationship between PA and mental health.

Happiness, as a positive component of mental well-being, is generally defined as a subjective state of mind characterized by enjoyment and contentment reflecting individual’s overall subjective well-being (Diener 2000; Veenhoven 2010). People rate happiness as one of the most fundamental goals of their lives (Diener and Seligman 2004). A growing literature has emerged highlighting the health benefits of happiness. For instance, a 15-year follow-up study suggested that higher levels of happiness are related with lower mortality and morbidity (Koopmans et al. 2010). Recently, several countries such as France, Canada, and the UK even included national happiness index as an indicator of national progress (Ghent 2011).

Among the factors associated with happiness, PA has received increasing attention among psychologists. Recent cross-sectional studies based on large general population have shown that PA is associated with happiness (Lathia et al. 2017; Richards et al. 2015). Some reviews indicate that the PA might be an important correlate of happiness and the investigation of the effects of PA on happiness would be a very promising research area (Diener and Tay 2012; Dolan et al. 2008). Such investigation is also thought to enable new channels to apply health promotion models to PA interventions (Huppert 2009).

Would PA also have beneficial effects on happiness as it does on other mental health constructs such as depression and anxiety? To answer this question, a review of existing literature concerning the relationship between PA and happiness seems timely. To the best of our knowledge, there has been no systematic review focusing exclusively on the relationship between PA and happiness. The primary aim of this study was to examine the association between PA and happiness through providing a meaningful synthesis of extant literature. Specifically, two research questions guide this review: (1) what type, duration, frequency, intensity or domain of PA is more consistently associated with higher levels of happiness, and (2) which groups of population are more likely to benefit from such associations.

2 Methods

2.1 Search Strategy

In June 2017, we comprehensively searched for original research articles published post-1980 in major databases including PubMed/Medline, PsychInfo, SportDiscus, and Embase. Terms and their variants used to identify relevant articles included: physical activity, exercise, happiness, subjective well-being, psychological well-being. The exact term combinations are: [(exercise*) OR (physical activit*)] AND ((happi*) OR (happy) OR (subjective well-being) OR (psychological well-being)). Titles and abstracts were screened to pre-exclude articles that did not meet the selection criteria. Full texts of the remaining articles were obtained and then screened by two independent reviewers for eligibility. Cohen's kappa (Cohen 1960) was reported as an index of agreement between reviewers. Reference lists of included articles were further examined to complete the search.

2.2 Selection Criteria

2.2.1 Types of Studies

Studies represented in original research articles and published in English-language journals were considered for inclusion. The review included both observational studies (cross-sectional and longitudinal) and intervention studies (randomized and nonrandomized). Unpublished articles, abstracts, and dissertations were not included in this review.

2.2.2 Participants

Since one goal of this review was to identify the populations that might benefit more from the effects of PA on happiness, there was no limit regarding the type and the age of participants. Both healthy populations and populations with certain diseases or chronic conditions were included in the review.

2.2.3 Outcome Measures

Studies considered for inclusion were required to have a specific assessment for individual's happiness level. Studies whose assessment tools were initially designed for mental health or well-being but later interpreted as happiness were excluded. Additionally, all the included studies should examine PA as an outcome either objectively or subjectively and incorporate at least one indicator for PA such as domain and frequency (for observational studies), or use PA programs as interventions (for intervention studies). All studies should clearly report the associations between PA and happiness or the effects of PA on happiness.

2.3 Data Extraction

The following information was extracted and summarized using a structured template by two reviewers independently: author details, year of publication; type of study, characteristics of participants (age, health status), sample size, measures of happiness, measures of PA or intervention details (type, duration, and intensity of PA), and main findings. In studies

that included outcomes other than PA and happiness, we only focus our analysis on PA and happiness. Disagreements in coding were resolved through discussion by two reviewers. No attempt was made to contact the authors of included articles for missing information.

3 Results

3.1 Search Results

Through the systematic search, a total of 1142 records were initially retrieved. After removal of duplicates 741 distinct records were identified for screening phase. The process of inclusion of the studies is presented in Fig. 1. After reviewing the title and abstracts, 29 studies were considered potentially eligible for inclusion. For these studies, full-text articles were obtained and assessed for eligibility, with 23 studies ultimately accepted for inclusion. The main reasons for exclusion were no specific measure for PA, no specific measure for happiness, or other constructs (mental health issues, life satisfaction, and quality of life)

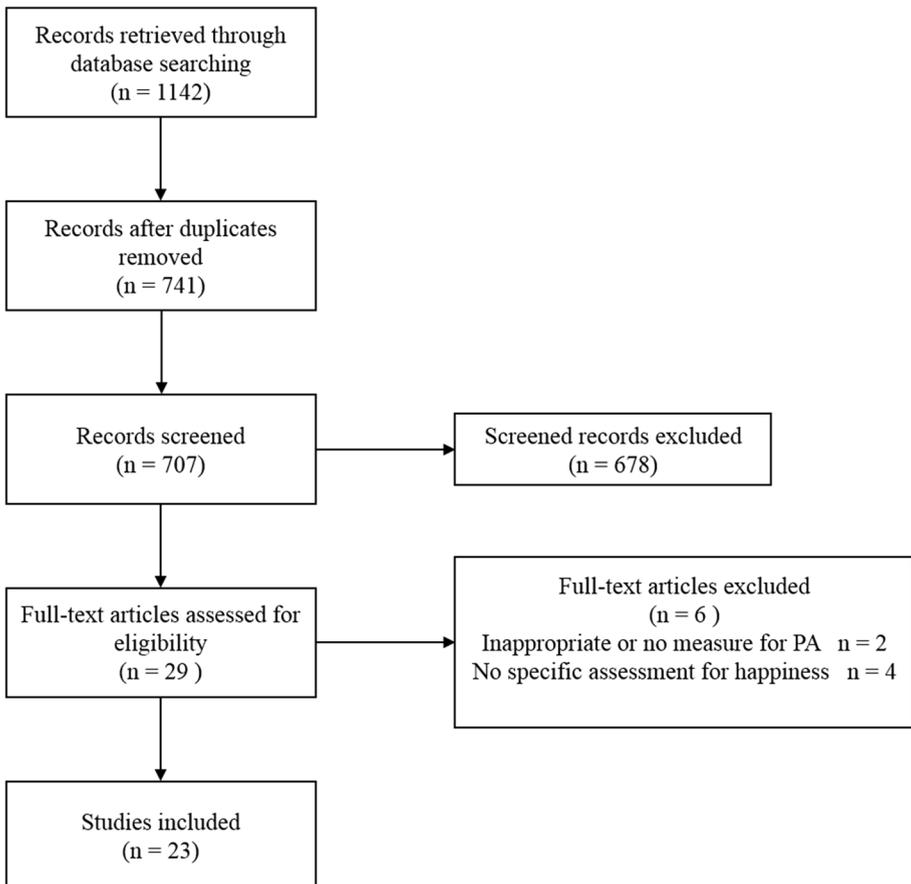


Fig. 1 Flowchart of study selection

were measured but later interpreted as happiness. The Cohen's kappa was 0.89, indicating high agreement between reviewers according to criteria suggested by Cohen (1960).

3.2 Characteristics of Included Studies

Among the 23 studies, fifteen were observational studies and eight were intervention studies. Except two articles were published in 2000, the rest of the included articles were published after 2007. The included studies were conducted at widely distributed countries, with eight from North America, eight from Europe, five from Asia, and one from South America and Australia each. Due to the different study designs, the results of observational studies and intervention studies were presented separately below.

3.3 Observational Studies

The comprehensive search identified thirteen cross-sectional and two longitudinal studies examining the relationship between PA and happiness (Table 1). The sample size of the observational studies ranged from 70 to 370,568, with the median sample size of 3461. Most of the studies comprised healthy population covering adolescents, adults, and older adults, except three studies targeting special population including children and adolescents with cerebral palsy (Maher et al. 2016), drug abusers (Nani et al. 2017), and ovarian cancer survivors (Stevinson et al. 2009). Happiness level was measured by single-item question in eight studies, such as "Over the past 4 weeks have you been a happy person?" and "In general, how would you describe your happiness?" (Barreto 2014; Baruth et al. 2011; Kye et al. 2016; Lera-López et al. 2016; Maher et al. 2016; Min et al. 2017; Richards et al. 2015; Wang et al. 2012). Other methods for assessing happiness level included Subjective Happiness Scale in three studies (Piqueras et al. 2011; Rasmussen and Laumann 2014; Stubbe et al. 2007), Fordyce Happiness Scale in two studies (Moljord et al. 2011; Stevenson et al. 2009), Oxford Happiness Questionnaire in one study (Nani et al. 2017), and scale on mood adjectives in the other study (Lathia et al. 2017), which all consisted of multiple items.

Among the fifteen observational studies, PA has been mostly assessed using self-reported measures with only one exception (Lathia et al. 2017) that adopted smart-phone sensors to collect PA data. The self-reported measures included International Physical Activity Questionnaire (Lera-López et al. 2016; Richards et al. 2015), Godin Leisure-Time Exercise Questionnaire (Nani et al. 2017; Stevenson et al. 2009), Physical Activity Questionnaire for Older Adults (Barreto 2014), Physical Activity Questionnaire for Adolescents (Maher et al. 2016), Youth Risk Behavior Surveillance System questionnaire (Min et al. 2017), Self-developed Historical Physical Activity Questionnaire (Baruth et al. 2011), Canadian National Population Health Survey (Wang et al. 2012), and single-item question on PA frequency (Kye et al. 2016; Moljord et al. 2011; Piqueras et al. 2011) or PA volume (Rasmussen and Laumann 2014; Stubbe et al. 2007). Derived from these self-reported measures, the outcomes of PA included total time spent doing PA per week (Lera-López et al. 2016; Rasmussen and Laumann 2014; Richards et al. 2015; Stevenson et al. 2009; Stubbe et al. 2007), metabolic equivalent (MET)-min/week (Barreto 2014; Baruth et al. 2011), number of days doing moderate or vigorous intensity PA per week (Kye et al. 2016; Min et al. 2017; Moljord et al. 2011; Nani et al. 2017), categories of PA levels (i.e. active or inactive) (Wang et al. 2012), extent of PA frequency (i.e. always or not always) (Piqueras et al. 2011), average score

Table 1 Main characteristics of observational studies investigating the relationship between physical activity and happiness

Author (year), country	Study design	Participants	Sample size	Measure of happiness	Measure of PA	Main findings
Barreto (2014), France	Cross-sectional	Older adults, mean age = 72.9	323	Single-item question	Physical Activity Questionnaire for Older Adults (QAPPA)	PA was indirectly associated to happiness, which was mediated by health status and social functioning
Baruth et al. (2011), USA	Longitudinal	Sedentary adults, aged 21–75	2132	Single-item question	Self-developed Historical Physical Activity Questionnaire	Men who were happier at baseline had greater increases in PA compared to men who were not happy; no relationship between happiness and PA was found in women
Kye et al. (2016), Korea	Cross-sectional	Adolescents, aged 12–18	72,435	Single-item question	Single-item question on PA frequency	A positive relationship between PA and happiness was found in boys but not in girls
Lathia et al. (2017), UK	Cross-sectional	General public, aged 15–44	12,838	Two dimensional affect grid; 7-point scale on mood adjectives	Real time self-report; smartphone sensor/built-in accelerometer	Both self-reported PA and objectively measured PA were positively associated with happiness
Lera-López et al. (2016), Spain	Cross-sectional	Adults, aged 50–70	765	Single-item question	International Physical Activity Questionnaire (IPAQ)	Leisure time PA was positively associated with happiness; this relationship is partially mediated by perceived health
Maher et al. (2016), Australia	Cross-sectional	Children and adolescents with cerebral palsy, mean age = 13.9	70	Single-item question	Physical Activity Questionnaire for Adolescents (PAQ-A)	PA was weakly associated with happiness in young people with cerebral palsy

Table 1 (continued)

Author (year), country	Study design	Participants	Sample size	Measure of happiness	Measure of PA	Main findings
Min et al. (2017), Korea	Cross-sectional	Adolescents, mean age = 15.1	370,568	Single-item question	Youth Risk Behavior Surveillance System questionnaire (YRBSS)	There was a positive relationship between PA frequency and happiness; this relationship was stronger among overweight adolescents
Moljord et al. (2011), Norway	Cross-sectional	Adolescents, mean age = 14.9	1508	Fordyce happiness scale	Single-item question on PA frequency	PA frequency was positively associated with happiness
Nani et al. (2017), Greece	Cross-sectional	Drug abusers, aged > 20	73	Oxford Happiness Questionnaire	Godin Leisure-Time Exercise Questionnaire	PA frequency was slightly positively associated with the respondents' happiness; no relationship between PA intensity and happiness was found
Piqueras et al. (2011), Chile	Cross-sectional	College students, mean age = 19.89	3461	Subjective happiness scale	Single-item question on PA frequency	PA frequency was positively associated with happiness
Rasmussen and Laumann (2014), Norway	Cross-sectional	Adults, mean age = 24.86	438	Subjective happiness scale	Single-item question on PA volume	PA level during adolescence was positively associated with happiness in adult
Richards et al. (2015), European Union	Cross-sectional	General public, aged > 15	11,637	Single-item question	International Physical Activity Questionnaire (IPAQ) short form	PA volume was positively associated with happiness; the association was domain-specific
Stevinson et al. (2009), Canada	Cross-sectional	Ovarian cancer survivors, mean age = 60.2	359	Fordyce happiness scale	Godin Leisure-Time Exercise Questionnaire	Meeting PA guidelines was positively associated with happiness.
Stubbe et al. (2007), Netherland	Cross-sectional	Adults from twin families, aged 18–65	8306	Subjective happiness scale	Single-item question on PA volume	PA was associated with higher levels of happiness.

Table 1 (continued)

Author (year), country	Study design	Participants	Sample size	Measure of happiness	Measure of PA	Main findings
Wang et al. (2012), Canada	Longitudinal	Household residents, aged > 12	17,276	Single-item question	National population health survey	Leisure time PA had a long-term positive association with happiness

of the questionnaire (Maher et al. 2016). Most studies controlled for potential confounding variables such as gender, age, body mass index (BMI), economic status and so forth. Two studies examined the mediation effect of the social functioning and health status (Barreto 2014), perceived health (Lera-López et al. 2016) on the relationship between PA and happiness.

The results from the included observational studies generally support the beneficial relationship between PA and happiness. All these studies found happiness was positively associated with PA, either directly or indirectly. Richards et al. (2015) found that there was a positive dose–response relationship between PA and happiness among citizens in 15 European countries. Compared with inactive people, the odds ratio of being happy was 20, 29, and 52% higher for people being insufficiently active, sufficiently active, and very active, respectively. Similarly, Lathia et al. (2017) found that PA measured by accelerometer in smartphones was positively related to happiness in 10370 smartphone users, although the correlation coefficient was only $r=0.03$. Two longitudinal studies provided stronger evidence. Baruth et al. (2011) examined the change in physical activity for at least 6 months among 2132 sedentary adults and found that men who were happy at baseline had greater increases in PA than those who were not happy at baseline. The results indicated greater level of happiness might lead to greater level of PA. Wang et al. (2012) examined both the leisure time PA and happiness at baseline and after 2 years among 17,276 Canadian household residents. The results showed that people who remained inactive at baseline and 2-year follow-up had 3 times the odds of being unhappy than those who were inactive at baseline but became active at 2-year follow-up. And those who were active at baseline but went inactive after 2 years had 1.7 times the odds of being unhappy than those who remained active at both baseline and 2-year follow-up.

Several studies investigated the relationship between happiness and PA exclusively among youth or adolescents. Min et al. (2017) and Kye et al. (2016) both found that the number of days doing moderate or vigorous intensity PA per week was positively associated with happiness among Korean adolescents. Engaging PA at least once per week, compared to none, had 1.4 times the odds of being happy in normal-weight adolescents and 1.5 times the odds in overweight adolescents. Likewise, Moljord et al. (2011) found that adolescents who participated PA two or more times per week had significantly higher happiness level than those engaged PA 1 day or less per week. Besides, Piqueras et al. (2011) found that college students who always participated PA had 1.3 times the odds of being happy than their peers who did not.

Three studies examined the relationship between happiness and PA in older adults. Barreto (2014) found that increased MET-min/week was associated with higher levels of happiness in older adults. However, this positive association was mediated by the health status and social functioning of older adults. Similarly, Lera-López et al. (2016) found that the total time in PA per week was positively related to happiness level in older adults and the relationship was partially mediated by perceived health.

Additionally, three studies investigated the relationship between PA and happiness among special population. Specifically, Stevinson et al. (2009) found that meeting public health PA guidelines (150 min of moderate/vigorous PA) was significantly associated with happiness level among ovarian cancer survivors. Maher et al. (2016) found that PA significantly predicted happiness level in children and adolescents with cerebral palsy. Nani et al. (2017) found that the times of exercise per week, regardless of intensity, were slightly associated with the happiness among drug abusers.

3.4 Intervention Studies

A total of eight intervention studies were identified in which six were RCTs and two were non-randomized trials (Table 2). The sample size ranged from 46 to 400, with the median sample size of 123.5. Participants in RCTs included older adults (Khazae-Pool et al. 2015; McAuley et al. 2000; Tse et al. 2014), cancer survivors (Cadmus et al. 2009; Courneya et al. 2009), and postmenopausal women (Courneya et al. 2017). The two non-randomized trials targeted the study population of college students (Mack et al. 2000) and primary school children (Yook et al. 2017). The happiness measures of these studies included Fordyce Happiness Scale (Cadmus et al. 2009; Courneya et al. 2009, 2017), Oxford Happiness Questionnaire (Khazae-Pool et al. 2015), Subjective Happiness Scale (Tse et al. 2014), Emotional Assessment Scale (Mack et al. 2000), Memorial University of Newfoundland Scale of Happiness (McAuley et al. 2000), Psychological Well-being Scale (Yook et al. 2017).

The types of PA programs implemented in the intervention studies included aerobic exercises (Cadmus et al. 2009; Courneya et al. 2009, 2017; McAuley et al. 2000), mixed school PA classes (Mack et al. 2000; Yook et al. 2017), and stretching and balance exercises (Khazae-Pool et al. 2015; Tse et al. 2014). All these studies clearly specified the time, frequency, and duration of the PA programs, with the time ranging from 30 to 75 min, frequency from once per week to five times per week, and duration from 7 weeks to 12 months. The intensity of PA programs was reported in four studies by indicating the percentage of maximum heart rate (Cadmus et al. 2009; Courneya et al. 2017) or the percentage of maximum rate of oxygen consumption (Courneya et al. 2009; McAuley et al. 2000).

Overall, the intervention studies that investigated the effects of PA on happiness showed inconsistent results, with 3 RCTs (Courneya et al. 2009; Khazae-Pool et al. 2015; Tse et al. 2014) and 1 non-randomized trial (Yook et al. 2017) reporting a significant difference in the change of happiness between intervention group and control group.

Four RCTs have investigated the effects of aerobic exercise on happiness, with two studies using no intervention or usual care as control (Cadmus et al. 2009; Courneya et al. 2009), one study using stretching exercise as control (McAuley et al. 2000), and the other study comparing high volume aerobic exercise and moderate volume aerobic exercise (Courneya et al. 2017). Cadmus et al. (2009) compared the effects of 30-min moderate to—vigorous intensity aerobic exercises with 5 times per week for 6 months with that of usual care among breast cancer survivors. The results showed that happiness level, which was measured by Fordyce Happiness Scale, was remained consistent in both intervention and control groups after 6-month intervention. On the contrary, Courneya et al. (2009) used the same assessment for happiness as Cadmus et al. (2009) did and found that happiness level improved significantly in intervention group but not in control group after 12-week intervention of 45-min aerobic exercise with three times per week among lymphoma patients. More recently, Courneya et al. (2017) compared the effects of different PA volumes (30 vs. 60 min of moderate-intensity aerobic exercise, both 5 times per week) on happiness among postmenopausal women and found that there was no difference in the improvement of happiness between moderate volume group and high volume group after 12-month intervention. Besides, McAuley et al. (2000) compared effects of moderate intensity aerobic exercise with stretching exercise among sedentary older adults, with 40 min each time and three times per week for

Table 2 Main characteristics of intervention studies examining the effects of physical activity on happiness

Author (year), country	Study design	Participants	Sample size	Intervention	Control	Measure of happiness	Main findings
Cadmus et al. (2009), USA	RCT	Breast cancer survivors, mean age = 55.2	125	30 min of moderate to-vigorous physical activity, 5x/week, 6 months	Usual care	Fordyce happiness scale	Happiness level remained consistent in both exercise and usual care groups
Courneya et al. (2009), Canada	RCT	Lymphoma patients, mean age = 53.2	122	45 min of aerobic exercise, 3x/week, 12 weeks	Usual care	Fordyce happiness scale	Intervention group significantly improved happiness level after 12-week aerobic exercise program while control group did not
Courneya et al. (2017), Canada	RCT	Healthy but inactive postmenopausal women, aged 50-74	400	Moderate volume group: 30 min of aerobic exercise, 5x/week, 12 months High volume group: 60 min of aerobic exercise, 5x/week, 12 months	NA	Fordyce happiness scale	There was no difference in change of happiness between moderate volume group and high volume group
Khazae-Pool et al. (2015), Iran	RCT	Older adults, mean age = 71	120	30 min of stretching and balance exercise, 3x/week, 8 weeks	Regular activities	Oxford Happiness Questionnaire	Intervention group significantly improved happiness level after 8-week PA program while control group did not
Mack et al. (2000), USA	Non-randomized	Undergraduate students, mean age = 19.6	74	75 min of volleyball, power walking or jogging class, 2x/week, 7 weeks	NA	Emotional assessment scale	Happiness level did not change significantly after 7-week PA courses

Table 2 (continued)

Author (year), country	Study design	Participants	Sample size	Intervention	Control	Measure of happiness	Main findings
McAuley et al. (2000), USA	RCT	Sedentary older adults, mean age = 65.5	174	40 min of aerobic exercise, 3x/week, 6 months	40 min of stretching and toning exercise, 3x/week, 6 months	Memorial University of Newfoundland scale of happiness	Both PA groups improved happiness after 6-month intervention and there was no difference in the change of happiness between groups
Tse et al. (2014), China	RCT	Older adults living in nursing homes, mean age = 85.5	396	60 min of stretching and balance exercises, 1x/week, 8 weeks	Usual care	Subjective happiness scale	Intervention group significantly improved happiness level after 8-week PA program while control group did not
Yook et al. (2017), Korea	Non-randomized	Primary school students, mean age = 10.98	46	40 min of yoga, running activity or Kin-Ball, 1x/week, 8 weeks	Regular activities	Psychological well-being scale	Intervention group significantly improved happiness level after 8-week PA program while control group did not

6 months. McAuley et al. (2000) found that happiness level significantly improved in both aerobic exercise group and stretching exercise group after 6-month intervention and there was no difference in the change of happiness between the two groups.

Two RCTs examining the effects of stretching, balancing exercises in older adults reported beneficial effects of PA on happiness. Specifically, Khazae-Pool et al. (2015) conducted 30-min stretching and balance exercise with 3 times per week for 8 weeks among older adults aged 65–89 years. This study found that intervention group significantly increased happiness level after 8-week while non-intervention group did not. Likewise, Tse et al. (2014) found that 8-week stretching and balancing exercises intervention, with 60 min each time and one time per week, significantly improved happiness level in intervention group but not in usual care group among older adults living in nursing homes.

Besides the RCTs, two non-randomized studies have investigated the effects of PA classes in students. Yook et al. (2017) found that happiness level changed significantly over 8-week intervention of PA classes, with 40 min each class and one class per week, including various sports activities and yoga among primary school students. In contrast, Mack et al. (2000) involved participants of undergraduate students and found the happiness level remained unchanged over 7-week intervention of PA classes including volleyball, power walking, and jogging, with 75 min each class and two classes per week.

4 Discussion

This literature review examined the existing evidence concerning the relationship between PA and happiness. A total of fifteen observational studies and eight intervention studies were systematically reviewed to identify which aspects of PA were more consistently associated with happiness and what kinds of population were more likely to benefit from the effects of PA on happiness. This review extends prior knowledge of the relationship between PA and mental health by focusing the positive dimension of mental health. The research findings generally support the beneficial relationship between PA and happiness. Of the thirteen cross-sectional studies, the positive relationship between PA and happiness was found among a wide range of population. Although the cross-sectional studies could only provide correlational evidence, potential confounding variables were controlled in most of the studies, thus adding the additional credibility to their findings. Two longitudinal studies provided stronger evidence demonstrating that PA may have a long-term positive association with happiness, with one study showing greater level of PA resulted in higher levels of happiness while the other showing the opposite direction that higher levels of happiness lead to increased PA. Six RCTs mainly involved cancer survivors and older adults showing that both aerobic exercises and balancing and stretching exercises were effective in improving individual's happiness level. Only one RCT reported no significant change in happiness after 6-month aerobic exercise intervention in breast cancer survivors. Two non-randomized trials examined the effects of PA class on happiness in youth and children but showing inconsistent results.

Our findings suggest that PA frequency and PA volume are essential factors in the relationship between PA and happiness, and more importantly, even a small change of PA makes a difference in happiness. Studies showed the significant difference in happiness levels between doing exercise 1 day per week and none per week. As little as 10 min PA per week might greatly increase the odds of being happy. Such pattern that small amounts of PA yield benefits was similar in the relationship between PA and other aspects of mental health, such as depression and anxiety (Dunn et al. 2001; Teychenne et al. 2008). In

addition, there seems to be a threshold effect for the relationship between PA and happiness. Several cross-sectional studies found that there was no difference in happiness levels between active individuals (150–300 min moderate to—vigorous PA per week) and very active individuals (> 300 min moderate to—vigorous PA per week). This was further supported by one RCT which compared the moderate volume of PA intervention (150 min aerobic exercise per week) with the high volume of PA intervention (300 min aerobic exercise per week) and found no difference in the change of happiness between two groups. There might not be an optimal type or intensity of PA in the relationship between PA and happiness. The RCTs have demonstrated aerobic exercise and stretching/balancing exercise were equally effective in improving happiness. The positive associations between PA and various intensities of PA (light, moderate, vigorous) were reported across observational studies. In addition, the relationship between PA and happiness might be domain-specific, in which leisure time PA showing the most consistent positive association with happiness.

Our findings indicate that overweight population might gain more benefits of PA on happiness than normal-weight population. It might be because overweight population is at higher risk of being unhappy and thus has more room to improve (Cornelisse-Vermaat et al. 2006). Gender difference was found in two studies, with males showing the positive association between PA and happiness while females not. One possible explanation may be that the men are more likely to participate in PA for the reason of enjoyment than women (Azevedo et al. 2007). Only a few studies have explored the potential mechanism of the effects of PA on happiness. Mediators were found in two studies, in which health status, social functioning, and perceived health appeared to account for the relationship between the PA and happiness. It is consistent with previous studies which demonstrated social relationships and health were important determinants of happiness (Caunt et al. 2013). Previous studies have shown that there were some differences across cultures in terms of the causes of happiness, such as the relationship between self-esteem and happiness was moderated by individualism (Diener et al. 2013). Our results indicate that physical activity is consistently correlated with happiness in countries across various areas, indicating no cultural difference in the relationship between PA and happiness.

4.1 Limitations in the Existing Literature

Although there is a growing trend examining the relationship between PA and happiness, which could be indicated by the increasing number of publications in the recent years and by the global range where the studies were conducted, several limitations exist and make it relatively difficult to draw relatively conclusive inference. First, only a small number of RCTs has been conducted compared to observational studies. Furthermore, all these RCTs targeted individuals who were more likely to suffer mental health problems, e.g. older adults and cancer survivors. Therefore, there is a lack of the RCTs examining the effects of PA on happiness among healthy population. Second, a myriad of outcome measures was used in both observational and intervention studies, leading to the difficulties in synthesizing results across different studies. For example, near half of the studies used one-item question to measure happiness, which assumed that respondents understood that happiness was an overall evaluation of life, while other studies adopted well-validated questionnaires such as Subjective Happiness Scale, which consisted of multiple questions to measure individual's happiness level. Although there is no consensus regarding the "gold standard" of happiness measures, we believe that well-established, multiple-item scales of happiness will provide more credibility to the measurement. We recommend three mostly cited

measures of happiness, whose reliabilities and validities have been demonstrated to be high in different populations and various cultural contexts. These measures are Subjective Happiness Scale (Lyubomirsky and Lepper 1999), Fordyce Happiness Scale (Fordyce 2005), and Oxford Happiness Questionnaire (Hills and Argyle 2002). For the measures of PA, except one study used smartphone sensors to measure PA, the other studies used self-report approaches to assess PA. And among these self-report measures, various aspects of PA were captured due to different questionnaires used. For example, some studies only measured leisure-time PA and some only assessed the vigorous PA, and the recall period of PA also differed across these questionnaires. Third, although most studies reported a positive association between PA and happiness, only a few studies attempted to explore the mechanism of how PA impacted happiness or, reversely, how happiness impacted PA. Fourth, the dose–response relationship between PA and happiness remains largely unknown, especially given the limited evidence by intervention studies.

4.2 Suggestions for Future Research

According to the limitations, we suggest that future research address the following needs. First of all, more RCTs are needed to examine the effects of PA on happiness, especially among the general public and healthy populations. In addition, these future RCTs should make an effort to compare the effects of different types, frequencies, intensities of PA, and to explore the dose–response relationship between PA and happiness to determine whether there is an optimal dose of PA for the improvement of happiness. Second, we suggest that future studies investigate the underlying mechanism of the effects of PA on happiness, or the effects of happiness on PA. For example, PA might increase happiness level via several physiological or psychological pathways, which have already indicated by a few studies. Disentangling the relationship between PA and happiness might expand the strategies for the PA intervention in health promotion. Third, objective measure of PA, such as using accelerometers or smartphone sensors, is needed for both observational and intervention studies in future research. On the one hand, the objective measures and subjective measures of PA could lead to largely different results since the subjective measures of PA may result in self-report bias (Troiano et al. 2008). On the other hand, by objectively measuring PA, we could separate the effects of PA per se from other elements during the process of PA, such as social interaction. In addition to addressing these limitations of the existing studies, we suggest future studies extend the research focus to the relationship between PA and other positive psychology related concepts, such as life satisfaction, optimism, and hope. Investigations of the relationships between PA and these concepts help us better understand how PA shapes people's lives in positive ways. Moreover, we recommend that future research should investigate the relationships of physical fitness and sedentary behaviors with happiness. Previous studies have shown that sedentary behaviors and lower physical fitness are associated with increased risks of mental health issues (Hoare et al. 2016; Schuch et al. 2016), but studies of their relationships with positive mental constructs have been lacking.

4.3 Limitations of the Current Review

This review only included studies published in peer-reviewed journals with English language, which might lead to potential publication bias and thus overestimating the positive relationship between PA and happiness. Although we searched the main databases for

biomedical and psychological research, other databases, such as Scopus and Web of Science, may cover extra relevant studies. Due to the limited number of RCTs, we could not draw causal inference on the relationship between PA and happiness. The quality of the included studies was not assessed in this review and we did not weight the findings based on the rigor of individual study. Quantitative synthesis was also not conducted due to the limited evidence and the large variability across the studies.

5 Conclusion

This review identified fifteen observational and eight intervention studies which investigated the relationship between PA and happiness. The available evidence indicates the positive relationship between PA and happiness among wide range of population. As little as 10 min PA per week or 1 day of doing exercise per week makes differences in happiness level. However, numerous aspects have remained largely unexplored. More research is necessary to determine the optimal dose and type of PA for gaining the benefits of happiness, and explore the pathways through which PA would possibly affect happiness. More RCTs are warranted for future research in order to draw causal conclusions.

Compliance with Ethical Standards

Conflict of interest The authors declare no conflict of interest.

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