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A SYSTEMATIC REVIEW OF PHYSICAL ACTIVITY INTERVENTIONS TO IMPROVE PHYSICAL ACTIVITY LEVEL, FITNESS AND HEALTH OUTCOMES AMONG ADOLESCENTS

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Autor: Kingsley Ginika,

Physical Activity and Active Living

Vedoucí práce: Michal Kudláček, Ph.D.

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Supervisor: Michal Kudláček, Ph.D.

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Abstract:

Background: Lack of physical activity (PA) and high levels of sedentary behavior (SB) have been associated with health problems. Although PA is considered to yield substantial health benefits, the level of PA among adolescents' is not sufficient. Adolescence is characterised by a decline in PA level. Many studies investigated the effectiveness of interventions promoting PA among adolescents, but majority of the interventions are multifaceted involving diet, PA etc. The aim of this study is to evaluate and review physical activity interventions to improve physical activity level, fitness, and health outcomes among adolescents. **Methods**: A systematic review was conducted to identify PA intervention studies published in the scientific literature for the past two decades. Four databases were searched, reference lists were scanned, and the publication lists of the authors of the retrieved articles were checked. **Results**: The literature searched identified 9 relevant studies. All the interventions were delivered through the school setting of which one included the use of the internet. Five of the interventions included the use of objective measures. Three of the intervention were based on theoretical models while six of them are multicomponent approach which involved the use of objective measures. None of the interventions included direct family involvement. The main findings of the review were: (1) School-based interventions generally lead to short term improvements in physical activity levels; (2) A sustained and realistic intervention can increase adolescent physical activity; (3) Multicomponent means of increasing physical activity among adolescent is better **Conclusion**: The overall literature supports the short-term effectiveness of school-based physical activity intervention. However, evidence to show its long-term effect or sustainability is still shrouded. Therefore, it is exigent for studies to implement a long-term intervention plan while carrying out their studies.

Keywords: Physical activity, adolescents, intervention, promotion, health, physical activity guidelines

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I hereby declare that I have completed this Master thesis independently under the supervision and help of Michal Kudláček, Ph.D. Special thanks go to my closest ones, who supported me during my studies.

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INTRODUCTION

It is widely agreed that engaging in physical activity (PA) is an effective preventative measure for a variety of health risk factors across all age, gender, ethnic and socioeconomic subgroups (Janssen et al, 2010; Paterson et al., 2010; Warburton et al., 2010). PA is described to involve all types of movement, from the smallest to the most complex. It may be voluntary, (including structured physical activity, planned, relatively limited in time and implemented to improve certain attributes of physical fitness or energy expenditure) or daily life activities (including walking, household, occupational activities or transportation). Teixeira et al (2006) described physical activity as an activity that can be typically involuntary and involves spontaneous movements, from small body movements, like a blink of an eye, to all muscle contractions associated with different postures of the body. But it is quite a task to assess and quantify separately these different physical activity domains, which leads them to being considered together. PA, is therefore defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen et al, 1985) and it has been shown in different studies to be beneficial to indicators of physical (Janssen et al, 2010) mental (Biddle et al, 2011) and psychosocial (Sprult et al., 2016) health in child and adolescent populations (Poltrasetal, 2016).

Adolescence is a formative phase of life during which patterns of growth, development, and behavior lay a foundation for health in later life and for the next generation (Patton et al., 2016, 2018). Adolescence has been defined chronologically by the World Health Organization (WHO) in 1965 and 2014 as being between the ages of 10 and 20, recognizing that this is a definition of statistical convenience rather than one which identifies the precise timing of the biological, social and psychological changes which characterizes it. Adolescence is generally categorized into three stages: early (»10 - 14 years old), middle (»15 - 17 years old), and late adolescence (»18 - 21 years old); cumulatively adolescence represents a period of marked changes in physical, psychological

and social health and well-being (Taylor et al., 2016, WHO, 2012). Adolescence is an opportune window where intervention and support can capitalize on youth readiness to practice new self-regulating skills.

It is worrisome that a large population of adolescents spend most of their discretionary time engaging in sedentary pursuits (e.g. watching television (TV) or playing video games) (Colley et al., 2011; Matthews et al., 2008). It was reported that in the U.S. children and youth spend an average of 6-8hours per day being sedentary (Kirk et al., 2009; Whitt-Glover et al., 2009). This is in line with a report by the World Health Organization (WHO), stating that 80% of the world's adolescents are not active enough (WHO, 2018). In addition, evidence has suggested that most adolescents do not achieve the 60 minutes per day recommendation and PA guideline (Pate et al, 2002). It is well known that most behaviors develop during childhood and early adolescence and these behaviors affect health throughout the life course (Telama et al., 2005; Van de laar et al., 2010).

The positive effects of PA cannot be overemphasized but unfortunately, studies and evidence has shown simultaneously a decline in PA among the adolescent population. (Sprult et al., 2016). Thus, only about 20% of adolescents worldwide meet the PA guidelines (Hallal et al., 2012), which is in line with the report of the WHO. This alarming evidence is the reason why a paper published on behalf of the Society for Adolescent Health and Medicine (Taylors et al., 2016) emphasize an urgent need for effective behavioral strategies to promote the health and well-being of adolescents.

Perhaps, creating programs to encourage adequate PA which represents a potent health promotion strategy; and participation is associated with improved physical fitness, decreased risk of chronic disease, and ultimately increased life expectancy (Ambrose & Golightly, 2015; Warburton et al., 2006).

1 LITERATURE REVIEW

1.1 Health in adolescents

Adolescents aged 10–19 years have been overlooked in global health and social policy (WHO, 2015). Adolescence is a vulnerable phase in human development as it represents a transition from childhood to physical, psychological, and social maturity. During this period, adolescents learn and develop knowledge and skills to deal with critical aspects of their health and development while their bodies mature. Adolescence is a crucial phase in life for achieving human potential, but one that needs specific investment (Patton et al., 2016). Such investments bring a triple dividend of benefits for adolescents now, for their future adult lives, and for the next generation. Their health and well-being are engines of change in a drive to create healthier, more sustainable societies (Patton et al., 2016). The Global Strategy for Women's, Children's, and Adolescents' Health (2016–2030) identified adolescents as central in achieving the Sustainable Development Goals (SDGs). Although much remains to be done in pursuit of the unfinished agendas of Millennium Development Goals 4, 5, and 6 (Every Woman Every Child, 2015). It is time to intensify efforts so that adolescents are not left behind, as health care continues to improve for maternal and child health.

However, for years, the unique health issues of adolescence have been little understood or, in some cases, ignored across countries and regions (Bundy et al., 2018). The Global Burden of Disease Study has shown that adolescents are facing new health challenges, including injuries, mental health issues, obesity, and early sexual behavior and pregnancy (Mokdad et al., 2016). Many key risk factors that underlie the major noncommunicable diseases usually start or are reinforced in adolescence, including diet and exercise pattern, tobacco, and alcohol use, overweight, and obesity (Alwan et al., 2010). Therefore, policies and interventions are warranted to improve health and reduce the burden of disease in adolescents. Health risks in general population vary substantially by

sex, age, and country (Mokdad et al., 2016), and thus applies to adolescents. Risk factors for non-communicable disease (NCD), which has been reported to being the leading cause of premature adult deaths, are often acquired in adolescence and these include alcohol or tobacco use, lack of PA and these leads to an increased risk of overweight, obesity and diabetes and, ultimately, to a higher risk of NCDs across the life course (WHO, 2015).

Adolescent health is shaped by broader determinants, including economic development, urbanization, social norms, household income inequality, and educational opportunities (Bundy et al., 2018). Government policies have the potential to shift many of these determinants, but the most part have not focused on adolescents compared with younger children. This is likely to be one reason why adolescents have had fewer gains in health compared with other age groups (Patton et al., 2016). This is now changing. In 2014, World Health Organization (WHO) issued the Health for the World's Adolescents: A Second Chance in the Second Decade (WHO, 2014), arguing that the gains from investments in maternal and child health were in jeopardy without corresponding investments in adolescent health. They recommended the development and implementation of national health promotion and health protection policies for adolescents.

In 2015, Global Standards for Quality Health-care Services for Adolescents were developed by WHO and the United Nations Program on HIV/AIDS (WHO, UNAIDS 2015). It presented eight Global Standards for improving the quality of health care for adolescents, with guidance on actions at multiple levels, including the review of laws, policies, and service systems. On September 25, 2015, in collaboration with different countries, the United Nations (UN) set 17 SDGs to end poverty, protect the planet, and ensure prosperity for all (United Nations, 2015), including ensuring healthy lives and promoting well-being at all ages. In the same year, the H6 agencies (United Nations Program on HIV/AIDS, United Nations Population Fund, United Nations Children's Fund, UN Women, WHO and the World Bank Group) initiated The Global Strategy for Women's, Children's

and Adolescents' Health 2016–2030 to support Every Women. The Global Strategy for Women's, Children's and Adolescent's Health 2016-30 was launched to foster a world in which "every woman, child and adolescent in every setting realizes their rights to physical and mental health and well-being, has social and economic opportunities, and is able to participate fully in shaping prosperous and sustainable societies" (WHO, 2015). Every Children Global Strategy and related SDG targets, prioritizing adolescents for the first time in a global strategy (United Nations, 2015).

About 1.2 billion adolescents (10-19 years) in the world today represent 16% of the global population, and the regions of South Asia, East Asia and the Pacific have the largest share of adolescents in the world with around 650 million (UNICEF, 2019). In 2016, more than 1.1 million adolescents died and the main cause of adolescent deaths was road traffic injuries; other major causes include self-harm, HIV/AIDS, interpersonal violence, lower respiratory infections, diarrheal diseases, drowning, and complications during pregnancy and childbirth, which is the leading cause of deaths globally among girls aged 15-19 years old (UNICEF, 2019). About 80% of adolescents are reported to be inactive or in other way do not meet the physical activity recommendation. WHO recommends at least 60 minutes of moderate- to vigorous-intensity PA accumulated every day for adolescents (WHO, 2015). However, the majority of adolescents in Asia-Pacific countries and territories do not carry out sufficient amount of physical activities every day, and the prevalence of inactivity in the region is the highest in the world (Guthold et al., 2020). In the Republic of Korea and the Philippines more than nine out of ten adolescents were inactive, while in Bangladesh about three out of ten adolescents did the recommended PA daily (Dong et al., 2020). In all countries and territories in the Asian region, inactivity was more prevalent among female adolescents than male adolescents.

1.2 Adolescents years

Adolescence as defined by the World Health Organization (WHO) is the period between 10 and 19 years and is considered one of the most rapid phases of human development (WHO, 2015). Adolescence is described as a turbulent and sensitive period with many developmental changes taking place e.g., biological, psychological, and sociological. The endocrine system, including hormonal alterations that occur during puberty are responsible for these changes that result for example in changed physical appearance, as well as changed behavior and feelings (Smith et al., 2011). Such changes, in addition to changes in the social and school context, can be frustrating and a burden to adolescents which leads to increased stress levels (Baghurst et al., 2014), this is said to be one of the reasons why adolescents don't engage in physical activity and rather get preoccupied in sedentary activities. The developmental changes that are seen in the brain during adolescence are largely dramatic over the human Physical activity and well-being among adolescent's lifespan (Smith et al., 2011). However, the developmental importance and the vulnerability of the adolescent brain, together with indications of greater release of hormones in young individuals, i.e stress hormones, growth hormones, may make adolescents more receptive to stress than older individuals as reported in the studies by Arnsten (2009), Lupien et al. (2009), Romeo et al. (2006). It has been established that stress during adolescence strongly associates with depressive disorders in adulthood (Turner & Lloyd, 2004).

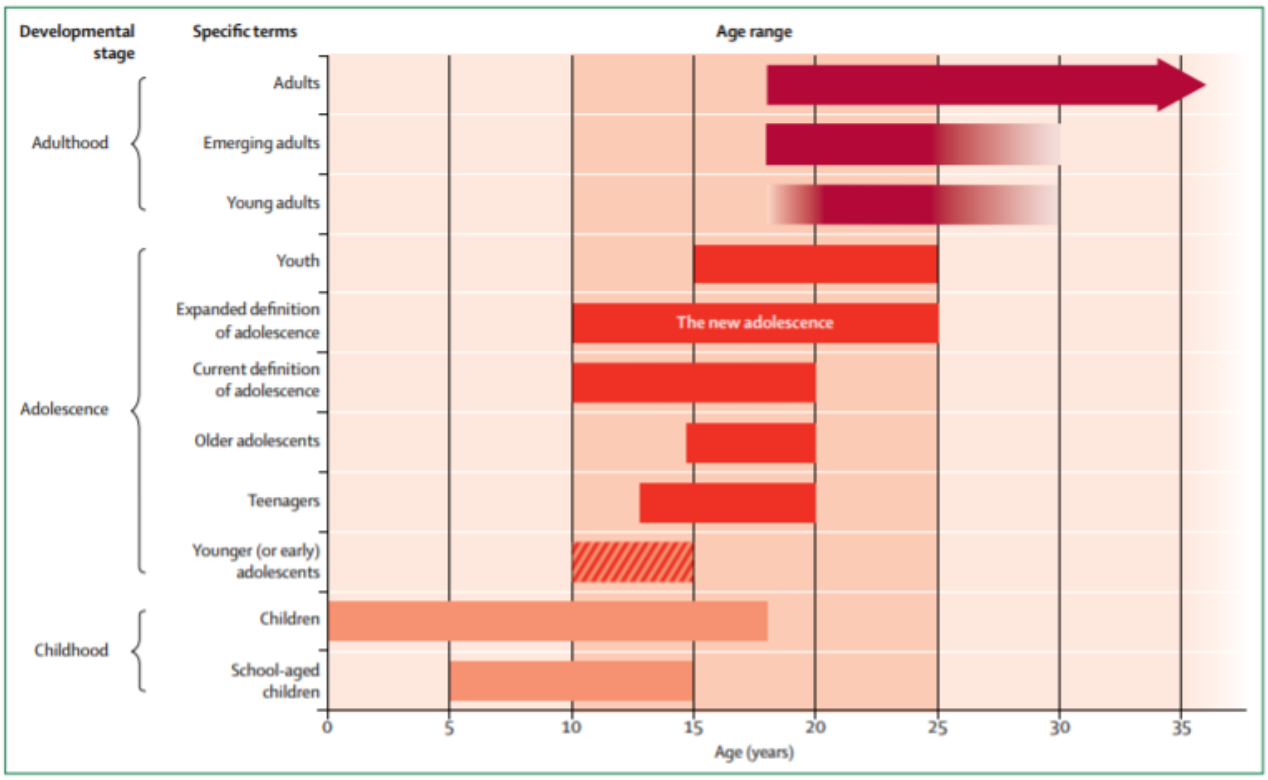

Figure 1: **Commonly used age definitions of specific terms of relevance for adolescence that span or overlap with the developmental periods of childhood, adolescence, and adulthood**
Colour shading highlights variation in the lower and upper age limits of the term. Stripes denote a term that sits within more than one developmental stage.

(Sawyer et al., 2018).

However, the health of adolescents has not received enough attention which has resulted in less improvements in adolescents' health compared to the health of younger children over the past 50 years (Sawyer et al., 2012). Acknowledging this, WHO has recently put extra focus on adolescents' health (WHO, 2014). Health among adolescents has been described essentially in terms of four major notions like health practice, Not being sick, feeling good and being able to do the desired and/or required activities (Boruchovitch et al., 2002). Although, adolescents are often regarded as a healthy group, this period is complicated with many challenges that can both be life-enhancing as well as life-threatening. The risk-seeking behavior of adolescents together with poor rational decision making could be tentatively explained by a developmental imbalance as there is a disparity in maturation between the limbic system (regulates reward processing, appetite, and pleasure seeking) and the prefrontal cortex region of the brain (the site of executive control functions

including decision making, emotional regulation and planning) during early to mid-adolescence (Sawyer et al., 2012).

Thus, many adolescents die prematurely because of accidents, suicide, and illnesses that could be preventable or treatable and many more suffer from chronic ill-health and disability with depression being the leading cause (WHO, 2014). As illnesses and disabilities can hinder adolescents in growing and developing to their full potential as well as having negative influence on their later life, it is important to focus on adolescent health. Therefore, public health initiatives that focus on the adolescent years e.g., physical activity interventions, have the opportunity to improve health both in adolescence and later in life. It is of uttermost importance to find ways for adolescents to engage in PA.

1.3 Factors affecting adolescents health

Mortality and morbidity rates are common indicators used for measuring the population health in public health research (Pate et al., 1995; Warburton et al., 2006). However, in high income countries with low rates of mortality and morbidity, perceived health is appropriately used as indicator. Adolescents in general seems to have a broad understanding of health. Their overall sense of functioning seems to be important, which is associated with indicators such as physical, psychological, social and health behavior (Biddle et al., 2011). In a Canadian population health survey, investigating factors predicting 12-19-year-old adolescents` perception of health, Craig et al. (2012) found that even though physical health status was the most important predictor, several other components involving personal, socio-environmental and behavioral factors also had an important influence in their overall perception of health. Furthermore, negative perceived health among mid-aged adolescents has been associated with body dissatisfaction (Lee et al., 2012) and psychosomatic complaints. A qualitative study by Woodgate and Leach (2010) investigated how Canadian youths

framed their health within the context of their life situations, found that lifestyle factors were highlighted as the most important in their perception of health.

There are other studies that have also investigated how much adolescents understands their health and result shows similar patterns regarding adolescents understanding of health. Breidablik et al. (2007) investigated the relationship between self-rated health and several structural, medical, psychological and social variables and concluded that adolescent's perception of health includes a broad set of background variables, such as body concern, health compromising behavior and physical activity. It was also established that female adolescents tend to rate their health lower than their male peers (Kohl et al., 2012; Lee et al., 2012; Warburton et al, 2006). Regarding how age affects adolescent perception of health, there seems to be some inconsistency. While most studies conclude that perceived health decrease with age during adolescence (Lee et al., 2012; PAGA, 2008), a study by Kohl et al. (2012) found an association between increased age and higher rating of health.

1.4 Physical activity

There has been different definitions of Physical activity (PA) but the most acceptable definition is that which describes PA as "any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a basal level" (Caspersen et al., 1985). PA has immense health benefit as it has been established that physical inactivity is the fourth leading risk factor for mortality globally (WHO, 2016). As such, there is an urgent need to support PA participation across the life course.

PA is a broad term with subcategories and exercise is one of the subcategories. Exercise refers to a planned, structured, and repetitive bodily movement with the objective of improving or maintaining health, physical performance, or physical fitness (Poitras et al., 2016). Furthermore, physical fitness

is defined as a set of attributes that individuals can obtain by performing PA (Caspersen et al., 1985) and physical fitness is thus typically defined either in relation to performance or health. Physical fitness is an important health marker shown to be predictive of cardiovascular disease, morbidities, and mortality (Hainer et al., 2009; Ortega et al., 2008). Fitness is partially determined by age, gender, health status, and genetics and is influenced by environmental determinants. Establishing physical activity habits early in life is important for increased fitness especially during adolescence (Physical activity guidelines for America, 2008)

PA can be defined further into three dimensions, e.g., frequency, duration, and intensity and these three dimensions together constitute the dose of PA performed. Moreover, the relationship between the dose of physical activity performed and the fitness or health outcome is considered the dose response relationship (Poitras et al., 2016). Frequency refers to how often the activity occurs while duration refers to time, i.e., how long the activity lasts. The intensity of PA refers to the rate at which the activity is performed or the magnitude of the effort that is required to perform the activity and is therefore important in relation to physical fitness (WHO, 2010). Thus, moderate-intensity PA requires a moderate amount of effort and noticeably accelerates the heart rate, e.g., brisk walking while, PA of vigorous-intensity requires a large amount of effort and causes rapid breathing and a substantial increase in heart rate, e.g., running (Bouchard et al., 2007; WHO, 2010). Intensity is also defined in relation to the metabolic rate of the body where one metabolic equivalent (MET) is defined as the amount of oxygen consumed while sitting at rest (Jette et al., 1990). In the 2008 Physical Activity Guidelines for Americans, absolute intensity was defined into three intervals of metabolic rate <3 METs, 3-5.9 METs, and ≥6 METs which equals to light, moderate and vigorous intensity PA, respectively. In relation to public health guidelines for PA, the intensity is an important factor. Moderate-vigorous intensity PA (MVPA) has consistently been associated with numerous physiological and psychological health benefits in adolescents (Andersen et al., 2011; Biddle et al., 2011; Steele et al., 2008). Evidence has also shown that physical activity performed at light

intensities may exhibit unique associations with health (Pateet et al., 2008). Guidelines has also explicitly recommended vigorous intensity PA at least three days per week (WHO, 2010).

PA has many health benefits for young people (Gretchen et al., 2019). It is no gainsaying regular physical activity is essential during adolescence to maintain normal growth and development and to establish lifestyle PA patterns that will reduce risk factors for health problems in later life. The health benefits of PA among adolescents is well documented. They include improved cardiorespiratory and muscular fitness, bone and cardiometabolic health, and positive effects on weight status (Physical Activity Guidelines Advisory Committee, 2018). Also, evidence suggest positive impact of PA on cognitive development and prosocial behavior (Australian Government Department of Health, 2019). PA improves peoples' well-being and can help in preventing weight gain, obesity, and related Non-Communicable Diseases (NCD) (Sabina et al., 2020).

PA guidelines recommend that youth should participate in PA, of at least moderate intensity, for an average of one hour per day (Pate et al, 2000), however population surveys highlight that young people may not be meeting these guidelines (Centers for Disease Control and Prevention, 2000; Sallis et al., 2000). It has been reported that less than 20% of adolescents globally meet recommended levels of physical activity (Sluijs et al., 2020). In 2008, global prevalence of school-going adolescents aged 13-15 years not meeting this recommendation was 80.3% (Hallal et al., 2012), using information from school-based surveys from 105 countries. In the year 2010, another survey for school-going adolescents aged 11-17 years, including information from an additional 15 countries to the previous study, showed a similar global prevalence of 78.4% for boys and 84.4% for girls (Sallis et al., 2016). This data informed the decision of the world health Assembly in 2018 to push the target for the reduction of PA insufficient among adolescents to 15% by the year 2030.

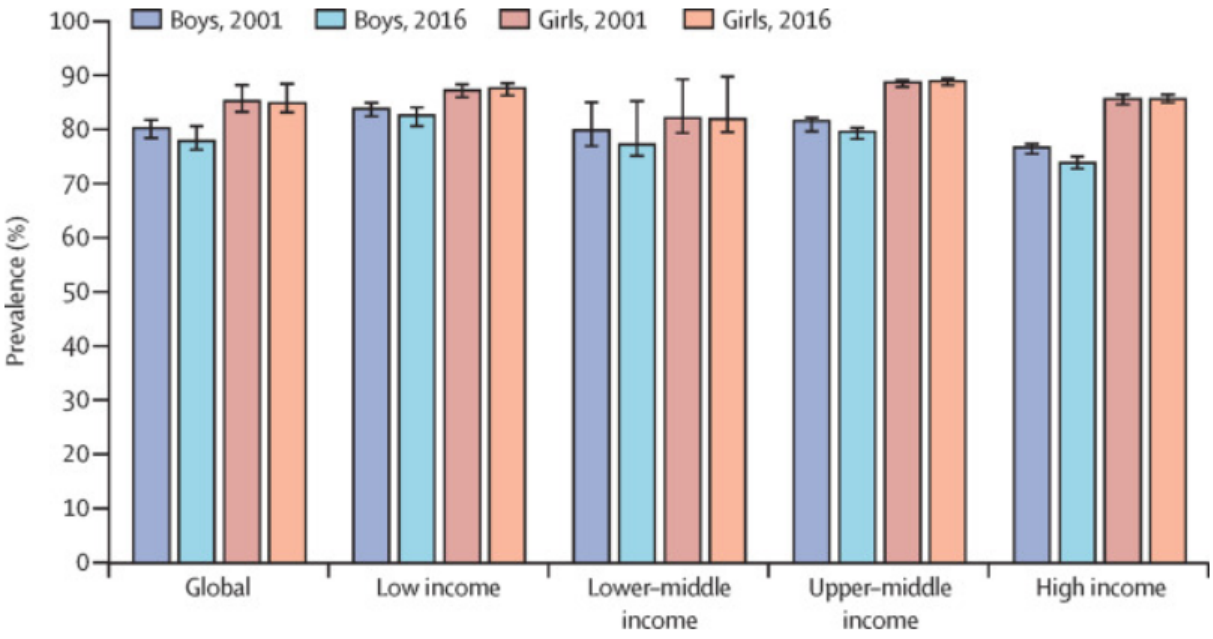

Fig 2: Prevalence of insufficient physical activity among school-going adolescents aged 11-17 years, globally and by world Bank income group, 2001 and 2016 (Guthold et al., 2020),

Adolescence provides an opportunity to influence attitudes towards activity, as many adolescents are still in the schooling system and under their parent's control. It is during the adolescent stage that identities are shaped and hence the belief that this is the time when behaviors are established. As posited by Andersen et al. (2002) that adolescence is an important period for learning health-related behavior patterns that will carry over into adulthood. Bauman, (2004) posited that what adolescents do may set the pattern for long periods of adulthood, as people establish many of their lifestyle choices as they proceed through adolescence therefore, promoting PA must start early in life. Adolescent physical activity improves adult health in three ways. Firstly, the direct effect of activity will improve adolescent health and in turn be beneficial to adult health. Secondly, an active lifestyle will have direct health benefits in later years by reducing risk factors. Lastly, an active adolescent is more likely to be an active adult thus lowering risk of disease (WHO, 2010). PA among adolescents is key as its suggested that PA during adolescents tracks into adulthood (Telama et al., 2014). Adolescents who are now referred to as Z- generation, are in a key phase of their lives. They make autonomous daily decisions in several aspects that can impact their level of PA, such as

short trips like the home-school travel or dates with friends. They are particularly interested in the environmentally friendly domain (Morris et al., 2000; Singh et al., 2016; Wiernik et al., 2013), that can push them in choosing an alternative means of transport that is healthy and sustainable. This feature should be harnessed in order to get the best out of them with regards to positive impact and involvement in PA.

PA is related to positive health outcome in adolescent (Strong et al., 2005). However, less than 50% of American youth meet PA guidelines when assessed via objective monitoring (Troiano et al., 2008). Moderate-to-vigorous PA declines by approximately 7% per year between the ages of 12 and 18 years (Dumith et al., 2011; Harding et al., 2015), and 80% of adolescents globally fail to satisfy current PA recommendations (de Moraes et al., 2013; Morley et al., 2012; WHO, 2018). Promoting PA in adolescents has been found to be effective in lowering risk of NCDs in adulthood (Ames et al., 2018; Van Cauwenberg et al., 2018; WHO, 2020; Young, 2006). It is without objection that PA in adolescents serves a lot of good and should be encouraged.

1.5 Physical activity guidelines

The first guidelines concerning PA were launched in 1975 by the American College of Sports Medicine (ACSM) (American College of Sport Medicine, 1975) and later updated in 1980 (ACSM, 1980). The guidelines were more focused on cardiorespiratory fitness rather than physical activity as such and recommended that people should engage in vigorous intensity aerobic exercise 3 times per week for 20 minutes each time (ACSM, 1980). This focus on aerobic exercise dominated the public health space until the early 1990s (Clow et al., 2014). However, as research evidence about the benefits of engaging in moderate intensity PA on health have accumulated, guidelines have changed from focusing primarily on fitness and exercise of vigorous intensity to emphasize physical activity of moderate intensity (Bouchard et al., 2007; WHO, 2010). Also, evidence about the dose-response relationship of PA influences the guidelines and emphasizes the importance of moderate

active versus sedentary habits (Geidl et al., 2019; Pate et al., 1995). At the same time, study reports on physical inactivity being an independent risk factor for various health outcomes has accumulated (Kohl et al., 2012; Lee et al., 2012; Professional Association for PA, 2010; WHO, 2010). For children and adolescents, the first PA guidelines were published in the United Kingdom in 1998 and were based on studies on children and youth (Janssen, 2007). Before that time, PA guidelines for children and adolescents were mostly consistent with the guidelines for adults (Janssen, 2007). The first guidelines for children and adolescents recommended daily physical activity of at least moderate-intensity averaging one hour while a much more comprehensive guideline recommendation emphasize the added benefit of more daily PA of moderate-to vigorous intensity or up to several hours per day (Department of Health, 2011). Although, different countries have adopted a guideline as it suits their environmental needs (Bellew et al., 2008). Moderate-to-vigorous PA (MVPA) refers to activities which results in increasing heart rate, sweating and breathing harder or being out of breath (Santos et al., 2009), such as brisk walking, skipping or bike riding. Furthermore, vigorous intensity activities, including those that strengthens muscle and bone, should be incorporated at least three days a week. The global public health recommendations from the WHO focuses on daily moderate to vigorous-intensity PA (WHO, 2010) while the older regional guidelines from the European Union focuses on moderate-intensity PA of one hour (European Union, 2008). Most countries guidelines are in accordance with the WHO public health recommendations on PA (WHO, 2010). However, concern has been expressed that the recommendations have only a limited scientific basis (O'Donovan et al., 2010), and the level of PA may not be enough to prevent weight gain (Andersen et al., 2006; Lee et al., 2010). According to these recommendations, children and youth aged 5-18 years should engage in at least 60 minutes per day of moderate to vigorous-intensity PA. The guidelines also recognize the additional health benefits of greater amounts of daily PA. Moreover, the WHO guidelines specify that most of the daily PA should be aerobic but vigorous intensity activities, including activities that strengthen muscles and bones, which should be incorporated at least three times per week (WHO, 2010).

However, despite numerous health gains of PA as documented by various studies(Bouchard et al., 2007; Ekelund et al., 2006; Hallal et al., 2006; Janssen et al., 2010; Pedersen et al., 2006; Penedo et al., 2005), worldwide only about 20% of 13–15-year-olds are meeting the guidelines for daily physical activity (Hallal et al., 2012), this is in agreement with the report of a study by (Currie et al., 2012), in the Nordic countries including Iceland, only between 12 and 23% of 11–15-year-old adolescents are meeting the PA guidelines. As physical activity develops during childhood and adolescence and is tracked into adulthood (Andersen et al., 2005; Scheerder et al., 2006; Suppli et al., 2013; Telama et al., 2005, 2014) this can have serious consequences for health and well-being also in later life. Consistent with the international physical activity guidelines issued by WHO (2020), the PA recommendations issued by various western countries all recommend children and youth participate in one hour per day of MVPA.

1.6 Patterns of physical activity

When studying the development of physical activity, it is important to differentiate between time-related and age-related trends in physical activity. The continuous supply of new technologies since the industrial revolution has made it easier for people to perform many work and household-related tasks with less physical labor needed and less energy expenditure. Also, the increasing possibility of new innovations related to communication and entertainment has resulted in more time spent being sedentary. Thus, this development has led to a general decrease over time or time-related decline in PA among adults as well as adolescents (Hallal et al., 2012). This has been stated in children in the study by Dollman et al. (2005). However, some controversy remains some reviews does not support this decline in youth, as reported by (Ekelund et al., 2011; Raustorp et al., 2010). Interestingly, studies among Amish people show different patterns of PA. The lifestyle among this group has remained the same for the last 150 years as they abstain from modern technology and still use labor-intensive farming methods similar to those used before the industrial revolution (Bassett et al., 2004). Indeed, studies on Amish adults (Bassett et al., 2004) and on Amish and Mennonite children

(Bassett et al., 2007, 2008; Esliger et al., 2010) reported high levels of PA compared to people living a contemporary lifestyle. Additionally, as reported by Bassett et al. (2004,2007), there is no age-related decline in PA among the Amish people as studies on adults (18–75 years) and youth (6–18 years) show similar amounts of accumulated steps per day or 16.311 and 15.563 steps/day, respectively, averaged over 7 days for both genders (Bassett et al., 2004, 2007). Overall, there is no decline in PA between 6 and 60 years of age in Amish people (Bassett et al., 2004, 2007). This is in total disagreement with the studies of Pratt et al. (2006) who found that PA decline most in adolescent from ages 15 through 18. This report was in close conformity with the finding of Sallis et al. (2000) who reported a decline in PA among adolescents and went further to say that the decline was at the steepest between the ages of 13 and 18. Evidence indicates a decline in the PA levels among adolescents during their teenage years up to early adulthood (Kemper et al., 2001; Leslie et al., 2001). The time-related decline in physical activity among contemporary people may have influenced age-related PA activity as the technological revolution may have different impact depending on age. A whole lot of evidence show age-related decline in PA, especially among adolescents (Barreira et al., 2015; Beets et al., 2010; Craig et al., 2013; Dumith et al., 2011; Jwkauc et al., 2012; Nader et al., 2008; Telama et al., 2000; Ortega et al., 2013; Roman et al., 2008) which may have a natural, biological basis related to the dopamine system that regulates motivation for locomotion (Sallis, 2000). However, as mentioned above, studies among the Amish people do not support the idea that the age-related decline in physical activity among people living a contemporary lifestyle could be a naturally occurring phenomenon explained by biological alterations in the dopamine system. Thus, the documented health benefits of physical activity (Biddle et al., 2011; Bouchard et al., 2007; Hallal et al., 2006; Penedo et al., 2005) are a good reason for finding appropriate methods for counteracting both the observed age-related and time-related decline of such activity on the population level.

1.7 Determinant of physical activity

Determinants are those factors that influence behavior. They may be biologically determined, or they may exist in the physical or social environment in which we live (Koeneman et al., 2011). In general, determinants can be characterized as facilitators (those that promote PA or reduce sedentary behaviors) and barriers (those that are perceived as discouraging behavioral change). Examples of facilitators are the availability of good facilities and an individual's level of confidence in the performance of specific activities, while lack of time, distance to facilities, and cost of supervised programs are examples of perceived barriers. Research has shown that determinants may vary in relation to type and intensity of overall daily PA (Sallis et al., 2000).

1.7.1 Personal factors

For adolescents, sex, age, ethnicity, and Socio-Economic Status (SES) level are major personal determinants of PA behavior. Sex is one of the most consistent demographic correlates of PA behavior in adolescence (Ammouri et al., 2007). Boys were more active than girls and an inverse association between age and PA was found in the study by Wu et al., (2005). Sex was identified to be a significant predictor of participation in PA (Ammouri et al., 2007; Higgins et al., 2003; Kristjansdottir et al., 2001; Loucaides et al., 2007; Raudsepp, 2006; Sherrick-Escamilla, 2004; Shi et al., 2006) This is also in agreement with the study of (Vilhjalmsson et al.,1998) who reported that adolescent females are less active compared with adolescent males.

Numerous studies have demonstrated that boys are more physically active than girls (Booth et al., 1997, 2002; van Medialen et al., 2000; Riddoch et al., 2007) and that engagement in physical activity declines with age during adolescence (Booth et al., 1997; Sallis, 2000; Telama & Yang, 2000; Trost et al., 2005; Pratt et al., 2006). Similar bearings have also been observed in young New Zealanders, results from the Sport and PA surveys indicated that, on average, boys spent 1.5 more hours being active each week than girls (Sport and Recreation New Zealand, 2003). The existing literature from developing countries suggests that the gender differences in PA among adolescents exist and it associates with several covariates. Studying PA in a Filipino youth sample it was found

that 87% of females reported no vigorous activities compared to 18% of males (Tudor-Locke et al., 2003). A study from Brazil reported that boys spent more time on sedentary behaviors but also more on physical exercise than girls (Suchert et al., 2015). Similarly, a study from Iran showed an identical pattern indicating that boys spent more time both on PA and sedentary behaviors than girls (Jalali-Farahani et al., 2016). Studies from way back in the early nineties also have similar report, the Dunedin Multidisciplinary Health and Development Study (DMHDS) of 799 adolescents aged 15 years found that boys reported an average of 11.9 hours per week of PA, while girls reported an average of only 7.7 hours per week (Reeder et al., 2010). Similarly, a national survey of the health of 12,934 students aged 12-18 years in 2001 found that 70.4% of male, and 57.3% of female students reported participating in moderate or strenuous exercise on three or more of the last seven days (Adolescent Health Research Group, 2003).

Furthermore, there was a purported decline in physical activity across the adolescent categories, the proportion of adolescents who were highly active between ages 9-12 years was 76% (boys) and 43% (girls) and it was 47% (boys) and 26% (girls) at 16-17 years of age. Physical inactivity (defined as less than 2.5 hours of PA per week) was also age-dependent, a report by the health department of the Australian government in 2015 revealed that about 47% of adolescents between the ages 13-15-year-olds were active and 30% of adolescents between 16-17-year-old were active. Within adolescent populations, establishing the effects of age and other personal traits related to PA behavior is further complicated by the biological changes that occur during maturation (Boreham & Riddoch, 2001). Interestingly, Kemper et al. (2001) reported that “late maturers” were more active than “early maturers”, hinting at a biological basis for physical activity participation. The study of (Shokrvash et al., 2013) did not find any significant association between age and PA and this is dissimilar to findings from previous investigations where age was found to be a significant predictor of physical activity among adolescents (Mushtaq et al., 2011; Wagner et al., 2004). However, it was speculated that it may be due to limited age range in the study sample. Age was inversely associated with adolescents’ PA in the report of studies by (Kristjansdottir et al., 2001; Neumark-Sztainer et al.,

2003). As adolescents became older, the level of PA decreased. However, the study by (Shi et al., 2006) found that age was not significantly correlated with PA.

Several studies have investigated the influence of ethnicity on PA in young people. Wold and Hendry (1998) summed up the effect of culture on PA in the statement: “Nations and countries differ in the value and meaning attached to PA in their culture and these differences are expected to result in different activity levels”. Bann et al., (2019) reported an average activity level difference both between and within regions. At this stage, it is necessary to define the terms “culture” and “ethnicity”, as they are often used interchangeably. Although they are directly related, ethnicity is the ethnic group or groups that people identify with or feel they belong to, while a person’s culture reflects the way in which people affirm identity and achieve a sense of belonging. In a cross-sectional survey of 2,026 primary and high school students in New South Wales, Australia, a large difference was observed in the prevalence of self-reported PA between girls from different cultural backgrounds. For example, the prevalence of adequate PA during winter terms (as measured by self-reported physical activity participation during a normal school week) among Year 8 European and Asian girls was 92.3% and 33.3%, respectively (Booth et al., 2002). In the US, there is evidence that Caucasian adolescents achieve greater levels of activity than those from minority ethnic groups (Aaron et al., 1993; Wolf et al., 1993). An international comparison of physical activity among young people from the 2001/2002 Health Behavior in School-Aged Children Survey (HBSC) (World Health Organization, 2004), found that the activity patterns of adolescents aged 11, 13, and 15 years varied widely across the numerous North American and European countries surveyed. Given New Zealand’s ethnic diversity (80% European, 14.7% Māori, 6.6% Asian, 6.5% Pacific, and 0.7% Other) (Statistics New Zealand, 2001) ethnic differences represent an important area. New Zealand’s Sport and PA surveys indicate that activity levels of young New Zealanders (aged 5-17 years) vary with ethnicity; Pacific Islanders (52% active) and those from “other” ethnic groups (59% active) were significantly less active than young Māori (71% active) or European (70% active) (Sport and Recreation New Zealand, 2003). Pacific Island girls were the least active (52% active)

among the different ethnic groups studied. This finding may be explained by the results of a qualitative study on the value of sport in 11-14-year old which reported that some Pacific Island parents were found to be very protective of their daughters and would not allow them to associate with boys or participate in male-dominated sports. Additionally, some Pacific Island females believed that they were expected to restrict their focus on sport and concentrate on academic or musical activities (Sport and Recreation New Zealand, 2005). The activity levels of Asian youth in New Zealand are not known, as they were not distinguished from other ethnic groups in the results of Sport and PA Surveys. However, findings from a comparative study of 1,200 adolescent females aged 10-16 years found that Indian and Chinese in New Zealand were significantly less active (as measured by pedometer step counts) than all other ethnic groups (Duncan, 2006).

Studies investigating the influence of Socio-Economic Status (SES) on PA among young people have provided variable results. A review of the correlates of adolescents' PA by Sallis et al. (2000) found that SES was unrelated to activity. Similarly, Aaron et al, (1993) noted that there were no significant associations between SES and PA levels in 1,245 males and females aged 12-16 years. In contrast, Inchley et al. (2005) reported that Scottish school children (11, 13, and 15 years of age) from lower SES groups consistently reported lower levels of vigorous PA as measured by self-report. Sallis et al. (1996) found that high SES school students participated in more PE classes, and in more activity lessons outside of school compared to low SES students. When referring to the relationship between SES and the type of activity performed, research by Santos et al. (2009) indicated that adolescents whose parents were of higher SES chose to participate in more organized sporting activities. Higher participation rates of out-of-school physical activities and organized sports by high SES youth may reflect their ability to afford the associated costs involved with taking part in these activities (e.g., fees, uniform costs). A study by La Torre et al. (2006), found a positive relationship between adolescents' participation in extracurricular PA and their families' high SES. In this study, the researchers investigated the extra-curricular PA of Italian adolescents, aged between 11 and 17 years, in relation to their families' SES. Extra-curricular physical activity was measured

by self-report questionnaire, and a SES family index was derived by considering parents' educational levels and work activities. SES and parents' education level were also consistent determinants of participation in PA (Voorhees et al., 2005). Gordon-Larsen et al. (2000) examined determinants of adolescents' PA and inactivity patterns. Maternal education was inversely associated with a pattern of high inactivity; having a mother with a graduate or professional degree was associated with an adjusted odds ratio (AOR) of 0.61 for high inactivity. High family income was associated with increased moderate and vigorous PA and decreased inactivity. Kantomaa et al. (2007) and La Torre et al., (2006) studied adolescents' PA, family income and parents' education level. High parental education level was associated with adolescents being physically active. High family income was associated with being an active sports club member in boys and girls. Adolescents' participation in different types of PA varied according to family income. However, Raudsepp (2006) found that higher social class was related to higher level of PA participation by adolescents, but the family's economic status was not related to the adolescents' PA level. Thus, he recommended that different PA and health promotion programs for adolescents and their parents must be developed that consider individual, social-environmental (family-level) and physical-environmental factors.

1.7.2 Psychological, cognitive, and emotional factors

Psychological factors are important determinants of PA behavior in young people (Sallis et al., 2000; Strauss et al., 2001). Attributes including personality, previous achievement, self-confidence, and perceived ability are all associated with PA. Self-efficacy, which refers to the confidence an individual has in being able to perform a behavior, has been widely linked with PA behavior in adults (Biddle, 2001). For adolescents, higher levels of self-esteem are also thought to positively predict PA levels. For example, Reynolds et al., (1990) found that self-efficacy correlated positively with physical activity behavior and predicted weekly PA participation in US adolescents aged 14-16 years. Additionally, in a review of physical activity behaviors among children and adolescents, Kohl and Hobbs (1998) stated that young people participate in physical activities for which they have

positive feelings. New Zealand adolescents have also identified building self-confidence as a reason that they find sport appealing (Sport and Recreation New Zealand, 2005).

Studies revealed the influence of perceived self-efficacy on PA among adolescents (DiLorenzo et al., 1998; Dowda et al., 2007; Jago et al., 2007; Loucaides et al., 2007; Motl et al., 2007; Neumark-Sztainer et al., 2003; Petosa et al., 2005; Wu, 1999; Wu & Jwo, 2005; Wu & Pender, 2003). Perceived self-efficacy was the most important predictor of PA, explaining about 19% of the variance in the PA among Taiwanese adolescents (Wu, 2005). In a comparative study of Taiwanese students and U.S. students, perceived self-efficacy directly predicted Taiwanese students' PA level, but indirectly predicted U.S. students' level of PA through the (mediation of perceived barriers and perceived benefits. Wu & Jwo, (2005) prospective study found that self-efficacy was correlated with PA in boys. Self-efficacy was a predictor of PA in boys in Phase 2 of a study by (DiLorenzo et al., 1998) and a predictor in girls longitudinally. However, Park et al. (2008) found that a significant relationship did not exist between perceived PA self-efficacy and PA. Motl et al. (2005) study also found that self-efficacy was not longitudinally related with changes in moderate and vigorous levels of PA; they found that perceived behavior control had a longitudinal independent relationship with change in vigorous PA. Dowda et al. (2007) found that perceived behavioral control was independently associated with age-related changes in PA. Individuals who perceive more exercise benefits and fewer exercise barriers are typically more active than those who report many perceived barriers and few perceived benefits (Nahas et al., 2003). Perceived barriers have been found to be an inverse predictor of PA in adolescents. Wu & Jwo (2005) compared differences in perceived benefits, perceived barriers, and perceived self-efficacy between students in Taiwan and the U.S. Perceived benefits of PA were found to be a direct predictor of PA in both groups. Perceived barriers did not directly predict Taiwan students' PA but did directly predict PA among the U.S. students. Duncan (2006) reported that perceived barriers to participation in PA accounted for 4.9% of the variance ($p < .01$) in self-reported total current level of PA in 10, 11 and 12year-old children. Chang (2004) found that among Asian-American youth, perceived barriers to PA were strongly and

negatively correlated with PA. The barriers identified most often were “not enough time”, “too much homework” and “too tired”. Robbins et al., (2003) identified the top barriers as being “I am self-conscious about my looks when I exercise” and “I am not motivated to be active”. Kimm et al., (2006) found that the most frequently cited barriers were “lack of time”, “I’m too tired”, and “they don’t interest me”. Neumark-Sztainer et al. (2003) found that time constraints were inversely associated with change in PA. A qualitative study was conducted by Dwyer et al., (2006) to determine adolescent girls’ perceived barriers to participation in PA. A total of 73 adolescent girls in Toronto participated in one of seven focus groups. Participants’ perceived barriers to participating in PA included: lack of time; involvement in technology-related activities; influence of peers, parents and teachers; concern about safety; inaccessibility of facilities and the cost of using them; competition; and body-centered issues. Lack of time is a major consistent barrier to adolescents participating in PA. In the studies of (Wu, 1999), it was observed that perceived benefits were positively associated with PA.

1.7.3 Socio-cultural factors

Social support is an important determinant of PA in adolescents, especially parental support and peer support (Ammouri et al., 2007; Dowda et al., 2007; Frenn et al., 2005; Higgins et al., 2003; Humbert et al., 2006; Motl et al., 2007; Neumark-Sztainer et al., 2003; Raudsepp, 2006; Trost et al., 2005; Voorhees et al., 2005; Wu, 2005). Parental influence is derived from the parents’ own behaviors as role models and their advice and support. Researches on social influence and youth PA suggests that parents, siblings, teachers, coaches, and peers all have a role to play in determining the participation and level of PA of young people (Duncan et al., 2004; Neumark-Sztainer et al., 2003; Strauss et al., 2001). Parental support was related to child’s PA both directly and indirectly through its positive association with child self-efficacy perceptions (Trost et al., 2005). Parental influence plays an important role in determining the activity behavior of young people either directly through modelling, or indirectly (Charlotte & Trish, 2010; Sallis, 2000), and has been shown to have both a

positive and a negative effect on PA behavior of young people. For example, parental influence encourages young peoples' PA participation by providing a supportive environment to perform and maintain regular activity (Welk et al., 2003; Zecevic et al., 2010). In contrast, lack of parental support and involvement has been reported as a barrier to participating in sport and PA among young people (Brandon et al., 2010; Hohepa et al., 2007; Sport and Recreation New Zealand, 2005).

Ammouri et al. (2007) reported a strong relationship with parents resulted to an increase exercise participation in older adolescent girls. Endendijk (2018) reported that fathers' explicit modelling towards boys was higher compared to girls. Fathers' and mothers' logistic support were significantly related to adolescents' PA (Charlotte et al., 2010). Fathers' explicit modelling was the strongest predictor of adolescents' PA, predicting 13.5% of the total variance (Raudsepp, 2006). Partially adjusted logit models revealed that family cohesion (odds ratio [OR], 1.09; 95% confidence interval [CI], 1.05–1.12), parent-child communication (OR, 1.13; 95% CI, 1.07–1.19) and parental engagement (OR, 1.25; 95% CI, 1.17–1.33) were all independent predictors of PA (Ornelas et al, 2007). In longitudinal analysis, Dowda et al. (2007) found that perceived family support was independently related to total metabolic equivalents (METs). Girls with higher values of perceived family support in the 8th grade had higher total MET scores in the 12th grade regardless of their values for self-efficacy or perceived behavior control. Girls who reported lower family support in the 8th grade had more rapid declines in PA, and a unit change in family support was related to approximately one third of a standard deviation change in total METs. These findings indicate that parents should encourage their children to participate in PA through a wide range of activities that include sports, recreation, transportation, work, planned exercise, and school-based physical education classes. In a cohort experimental study, Neumark-Sztainer et al. (2003) found that support for PA from parents, peers and teachers was positively associated with PA. During adolescence, the role of the family including both parents and siblings is still significant for physical activity participation (Duncan et al., 2004; Welk et al., 2003). An American study found that family support for PA was a strong and consistent correlate of PA in a national sample of Grade 4 - 12

school students (Sallis et al., 2000). In addition, stronger associations for girls rather than boys have been demonstrated between PA level and family support (Barr-Anderson et al., 2010; Yehuda et al., 2016). Wu et al. (2005) found that parental influence did not have any direct effects on PA, but peer influence had a significant direct effect on PA and also an indirect influence through perceived self-efficacy.

The role of friends in influencing PA behavior increases with age (Efrat, 2009; Salvy et al., 2012; Maturo & Cunningham, 2013), especially among girls (Adkins et al., 2004; Ommundsen et al., 2006). In the literature, the relationship between friends and physical activity behavior is often characterized as social support. Social support may be operationalized as three constructs: Instrumental and direct support (e.g., transport, financial assistance) Motivational support (e.g., encouragement) Observational support (e.g., modelling) (Prochaska et al., 2002). Scheerder et al. (2006) examined the relationship between sport and exercise involvement of teenage friends. Using self-report data from 394 girls with a mean age of 13.3 ± 0.3 years, they found that girls' perceptions of the sport and exercise involvement of their best friend was moderately correlated with girls' own sport and exercise involvement. In a similar study, the same authors reported the perceived activity of a best friend accounted for more explained variance when compared with family members. In a study by Prochaska et al. (2002), among a sample of 138 children (mean age = 12.1 ± 0.9 years), a weak but significant correlation ($r = .22$, $p < .05$) between self-reported level of PA and the perception that friends did PA or sport with them was reported. This association, however, was not apparent between accelerometer monitored individual PA and the perception that friends did PA or sport with them. Schofield et al. (2005) reported an association between friends objectively measured PA levels. Their study also examined the importance of the quality of friendship regarding influencing each other's behavior. In a qualitative study by Hohepa et al. (2007), peer influences were found to negatively affect PA participation among high school students in Auckland, New Zealand, with students reporting that a lack of interest from friends to be active and an absence of people to be active with, as perceived barriers to participating in PA.

1.7.5 Environmental factors

Physical environmental factors are major factors that exert a great influence on the PA behavior of adolescents (Pate, 2002). Increased independence during the later teen years allows for more influence from environmental determinants and undoubtedly influences the lifestyle of many adolescents. Van Der Horst et al. (2007) included access to facilities as a physical environmental variable in their study, and surprisingly found that there was no significant association between access to facilities and adolescents' PA which is in contrast to the findings of Humbert et al. (2006) who reported that low SES youth emphasized environmental factors (proximity, cost, facilities, safety) for their participation in PA. Seven studies that investigated the association between PA and environmental variables (De Bruijn et al., 2006; Gordon-Larsen et al., 2000; Humbert et al., 2006; Kristjansdottir & Vilhjalmsson, 2001; Loucaides et al., 2007; Motl et al., 2007; Shi et al., 2006) reported an association between equipment accessibility and its effect on PA through self-efficacy. Gordon-Larsen et al. (2000) found that participation in daily school physical education (AOR, 2.21; 95% CI, 1.82–2.68) and use of a community recreation center (AOR, 1.75; 95% CI, 1.56–1.96) were related with PA. De Bruijn et al. (2006) found that environmental perceptions were indirectly associated with PA. Loucaides et al. (2007) found that physical education classes were significantly associated with PA in rural school students. Commuting to school was associated with PA in urban school adolescents. Kristjansdottir et al. (2001) reported that urban students were more physically active than rural students. On the other hand, Park et al. (2008) found that PA was not significantly associated with where adolescents lived but in the report of the study by Fan et al. (2019) the type of living arrangement was associated with the PA of youth in Shanghai, with no significant gender difference. It was also stated that adolescents aged 9–19 years who lived with single parents had the lowest percentage of meeting MVPA recommendations. Davison & lawson (2006) studied the associations between the physical environment and young people's PA and they concluded that transport-related factors (such as the presence of footpaths, availability of public transport, a relevant place to walk to and low levels of traffic density) and recreation facilities (such as the

availability of equipment in parks and the facilities and infrastructure within schools) were positive correlates.

A supportive environment includes paying fees and uniform costs, providing transportation to practices and games, and providing encouragement. Physical environment conditions, such as access to equipment and facilities, are also thought to be strongly associated with PA behavior by younger age-groups (Davison & Lawson, 2006). An Australian study reported that girls would make more use of basketball courts during lunchtimes if their access to it was not restricted by the dominating presence of boys (Wright & Halse, 2014). Runar (2003) reported that within America there are gender differences in access to community-based sport and recreation programs and that this accounted for up to 6% of the gender difference in PA within their study. In a study by Hohepa et al. (2007), environmental variables were perceived as barriers to participating in PA in various contexts by a group of 44 Māori and New Zealand European Auckland high school youth. Students participated in focus group discussions based upon a standardized semi-structured interview schedule. A major theme that resulted from the focus groups was that the students' perceived environment was major barrier to being physically active. This perceived environment was seen to be more supportive of sedentary alternatives to being active. For example, students reported that there was "nothing to do" at lunchtime as schools restricted access to the gymnasium and sporting equipment. Distance to school was also a common theme identified by students as a barrier to active transportation while concern for safety in the surrounding neighborhood was found to be a barrier to active transportation especially acknowledged by female students.

Seasonal change is an environmental influence that has been found to affect PA behavior, however, many studies that have specifically evaluated this association have been conducted in an adult population (Merrill et al., 2005). Season and climate were found to influence PA among a nationally representative adult population in the US (Merrill et al., 2005). In their study, PA information was matched to weather data with results showing that a higher percentage of adults meet

recommendations for PA in summer, than in winter. In the Health Behavior in School-aged Children study, young peoples' PA patterns were found to vary according to the time of year as seasonal differences affected opportunities for outdoor activity (World Health Organization, 2004). An example of this variation was reported by Booth et al. (2002), who found that the proportion of girls who reported being vigorously active fell from 60% during summer school terms to below 50% during winter terms. The influence of seasonal change and climate has important implications for research methodology and sport and PA promotion programs (Merill et al., 2005).

1.8 Physical activity interventions

Interventions to increase PA in children and adolescents, can be successful considering multiple levels, combining the school with family, community, education and environment (van Sluijs et al., 2007), in a short-term (Shaya et al., 2008) or in a long-term (Brown et al., 2008). The development of interventions to increase PA levels in young people is a public health priority. Studies have shown that whole-of-school approaches including an educational component, encouragement of social support, and providing environmental conditions that enable PA seemed to be most effective (Haerens et al., 2006, 2007; Sallis et al., 2002; Simon et al., 2004). To increase PA among young people, researchers have developed and tested various PA interventions, many of which have been implemented in schools (vanSluijs et al., 2020).

In Australia, guidelines aimed at improving the health and wellbeing of children and adolescents through regular participation in physical activities and dietary recommendations (Vegetables, fruits, etc) are in place (National Health and Medical Research Council, 2013). However, a substantial proportion of adolescents in the country do not adhere to those guidelines (Daniels, 2009; Schranz et al., 2016). The 2018 report card for the Active Health Kids Australia (AHKA) indicated that Australian adolescents fell below the set targets for Active transport, sedentary behavior and PA (Schranz et al., 2016)

1.8.1 School Settings

Schools provide an ideal setting for PA promotion among adolescents since they have access to most of the population and the necessary facilities, equipment, and personnel to achieve this outcome (CDC, 2011). School-based intervention studies confirm that changing behaviors is a long-term and complex process to reach positive results. In Trial for Activity for Adolescent Girls (TAAG), during two years of school-based intervention, linked to PE, communities and marketing, each participant increased an average of 1.6 minutes of MVPA per day (Webber et al., 2008).

Other reviews that have looked more generally at school-based interventions to address PA in secondary school settings have reported mixed findings. A study looking at obesity prevention interventions found some evidence for PA interventions increasing levels of PA and reducing the risk of obesity in 13 -18-year-olds (Walls et al., 2011). However, love et al. (2019) reviewed school-based PA trials which had used objectively measured MVPA and found no overall effect on directly measured mean daily minutes of MVPA. Sutherland et al. (2016) conducted a high-quality study in a socio-economic deprived area, explicitly used the HPS framework, collected daily MVPA and showed a significant positive effect.

Health promotion conducted in schools can reach many young people, and this, coupled with existing school support structures and resources, underlies their popularity as settings for health promotion (International planning committee (IPC), 2006). The “Health Promoting Schools” framework was developed by the World Health Organization (1986) and is utilized extensively in many countries. Unfortunately, the success or otherwise of these programs is largely undetermined due to a paucity of research evaluating the effectiveness of such programs (Nutbeam, 2001). Improving school PE programs is documented to be the best approach to youth physical activity promotion (Nader et al., 1999; Pate et al., 2006, 2016; Sallis et al., 1992). Non-curricular school-based interventions have also been conducted with adolescents. Jago et al. (2004) evaluated the effectiveness of non-curricular interventions on the physical activity of children and adolescents and

it was reported that PA can be increased during school break periods, through existing youth organizations, summer day camps, and possibly through active transportation.

1.8.2 Out of School Intervention

It has been indicated from available evidence that most adolescents do not meet recommended 60minutes or more of moderate to vigorous PA per day. (Pate et al., 2008). Since a lot of students transition from formal school day to out-of-school programs, it has been emphasized that PA in adolescents can be improved or increased by participating in out-of-school supervised programs. Several researches have been carried out to validate the effectiveness of out-of-school interventions to promote PA in adolescents. Patrick et al. (2001) evaluated the PACE+ (Patient-centered assessment and counselling for exercise plus nutrition) program delivered in primary health care settings. Participants were assigned randomly to receive no further contact or 1 of 3 extended interventions: Mail only, infrequent telephone and mail, or frequent telephone and mail. In this study, a computerized screening was done followed by counselling from a health care provider. It was reported that there was no difference in self-reported moderate- intensity PA after four months (Patrick et al., 2001) between participants who received the extended intervention and those who received only the computer and provides counselling components. In a study by Ransdell et al. (2003) comparing two forms of exercise programs among 34 pairs of mothers and daughters: a community-based, instructor-led program and a home-based program (in or near home). Increases in self-reported participation in aerobic, muscular strength and flexibility activities were reported for both groups of 15year-old girls. Ransdell et al. (2003) also reported increases in indices of health-related fitness among the daughters in both groups. A six-month intervention with 57 low income, overweight African American girls that included interactive education/behavioral sessions focused on food, food preparation and PA, found no increases in PA (Resnicow et al., 2000). However, average attendance was low (43% of sessions). Similarly, in another study by Wilson et al., (2002) with African-American boys and girls, no significant changes in PA (measured by

accelerometry) were found following any of three 12-week after-school programs that employed different approaches: social cognitive theory (SCT) and motivational intervention; SCT only; education only. However, attrition resulted in measurements being taken from fewer than 15 participants per group at the end of the intervention. Also consistent with interventions targeting children, after-school programs were ineffective among. African American adolescents. Interventions based in primary care, however, may hold promise. Notable limitations of these studies include small sample sizes, the use of self-report measures and lack of long-term follow- up.

1.8.3 Pedometer-based (Wearable) intervention

Pedometers are a cost-effective and feasible objective measurement option (Lubans et al., 2015) and evidence from reviews and meta-analyses suggests that pedometer-based interventions are effective in promoting PA in children, adults and older adults of both genders (Bravata et al., 2015; Kang et al., 2009; Lubans et al., 2009). For example, a systematic review on the usefulness of pedometers shows that pedometer-based interventions among adults increase PA by 30% over baseline, are more effective for those with lower activity level at baseline and for those that use a step-diary (Bravata et al., 2007). Findings from several studies among young people indicate that step diaries and feedback are important components of pedometer interventions and that these are more effective with low active adolescents (Lubans et al., 2009). Hence, a 10-week pedometer- and diary-based PA intervention among 14-year-old adolescents shows increase in daily steps (Lubans et al., 2009). Similarly, a 5-week study based on pedometers and daily registration of steps among 13-year old students shows positive influence on PA (Shimon et al., 2009). Also, pedometers combined with step-diaries increase total PA in 15–16-year-old adolescents, especially girls, thereby eliminating the observed differences in PA between genders (Vasickova et al., 2013). Furthermore, pedometers in combination with logbooks and educational sessions enhance PA among low-active 16-year-old girls (Schofield et al., 2005). Additionally, an intervention study among 16-year-old adolescents demonstrates positive results when pedometers and self-efficacy theory are combined in a school-

based physical activity intervention program (Lee et al., 2012) and pedometers combined with a physical activity logbook increase PA in 18-year-old adolescents (Melnyk et al., 2014). According to the above discussed studies on adolescents, diaries with daily registration of steps in combination with pedometers are the most observed intervention components although both feedback and educational sessions are also mentioned. However, all the above studies use multicomponent interventions and therefore do not demonstrate if pedometers alone are effective in increasing physical activity or if other components are needed, e.g., PA diaries.

One of the first studies to incorporate eHealth technology into a pedometer-based intervention for adolescents was reported by Lubans et al. (2009, 2010). In this study, participants attended interactive seminars on goal setting and self-monitoring and were provided with pedometer and sent personalized email messages which is aimed at encouraging them to achieve their step count goals. It was reported that the intervention resulted in a significant increase in step counts for both boys and girls. The drawback for this intervention is the labor-intensive strategy for generating personalized feedback and it was concluded that this kind of intervention is not feasible for large population group.

In the works of Lubans et al. (2012) and Dewar et al. (2013) findings from the Nutrition and Enjoyable Activity for Teen Girls (NEAT Girls) intervention which used bulk short-message service (SMS) text messaging to reinforce health behavior change. In these studies, participants were provided with pedometers and sent weekly generic SMS messages during the intervention period. It was also reported that after 12 months, a post-test was done by an accelerometer to determine the Physical activity level of the participants but there was no effect (Dewar et al., 2014). It was concluded that Bulk SMS messaging was considered to have good reach, as messages were sent to 91% of girls. However, the participants described the messaging as “intrusive” because it was interfering with their daily activities.

A study on the Active Teen Leaders Avoiding Screen-time (ATLAS) program included a purposely built smart phone application to promote PA and reduce sedentary behavior in adolescent boys. In the Atlas app, there is a tailored PA message, which is based on information reported by participants, and once the app was downloaded, participants received biweekly messages sent through “push notifications” on the app (Smith et al., 2018). The participants really rated the app and it is concluded that this app may have utility for physical activity promotion in adolescents. An interesting study by Rote (2016), examines the change in PA whereby participants were asked to wear a Fitbit activity monitor throughout the semester. It was reported that there was a significant increase in physical activity among students who combined education and wearing of Fitbit activity monitor.

Pedometer based interventions has been identified to improve PA level of adolescents in various ways, very prominent are by self-monitoring and goal-setting based on personalized or standardized step targets (Home et al., 2009; Lubans et al., 2011), Open-loop feedback that involves making access to desirable sedentary activities such as television watching contingent on achieving step targets(Goldfield et al., 2006; Southard et al., 2006) and PA integration interventions that involve using pedometers as educational tools to increase PA throughout the school day (Oliver et al., 2006). However, some factors that can serve as limitations in using pedometer for improving PA in adolescents for instance, participants may become fatigues with wearing the pedometers and regress to their pre-intervention PA levels.

2. AIM OF THE STUDY

The purpose of this thesis is to evaluate and review physical activity interventions to improve physical activity level, fitness, and health outcomes among adolescents.

2.1. Research Question

Do physical activity interventions delivered among adolescents improve (a) Regular physical activity; (b) Physical fitness; (c) Health status?

3 MATERIAL AND METHODS

3.1 Eligibility Criteria

This systematic review focused on PA intervention in adolescents and studies where the primary outcome is promotion of physical activity.

Cross-sectional studies, case-control studies, cohort studies (Prospective and retrospective) and intervention studies (Including randomized and quasi experimental designs) were eligible for inclusion in the systematic review. Only published, English language studies including human participants were included. To be included studies had to be limited to adolescents between the ages of 10 -19 years, involving male or female participants.

For observational studies, there were no limitations placed on the form of PA (e.g., questionnaire, activity diary, pedometer, accelerometer) or fitness (musculoskeletal fitness) measurements. For intervention studies, all cardiorespiratory and/or musculoskeletal based interventions were eligible for inclusion. Intervention studies were not included in the table if they did not make promotion of PA as the primary goal of their study i.e studies including dietary (e.g., caloric restriction) or other behavioral risk factor component (e.g., smoking cessation) that may have independently affected the health outcomes and subsequently made it impossible to distinguish the independent effect of the PA portion of the intervention.

3.2 Search strategy

Literature searches were conducted in MEDLINE (2000-2020), EMBASE (2000-2020), all Evidence-Based Medicine Reviews (2000-2020) and SPORT Discus (2000-2020), Web of Science (2000-2020) ScienceDirect (2000-2020).

The electronic search strategies were executed by a single researcher (k) under direction of the supervisor (M). They were not restricted by publication type or study design; however, they were limited to human participants and English Language. The following string of search terms were

used for each of the study outcomes to identify physical activity related papers conducted within the age group of interest (‘physical activity’ OR ‘fitness’ OR ‘exercise’ OR ‘youth’ OR ‘Adolescents’ OR ‘Intervention’). The following search term was added (e.g., AND)

3.2.1 Screening of citations

After duplicate citations were removed from the Access database, the abstract of each citation was reviewed by single reviewer to determine if it should be included within the systematic review. The full-text articles of all potentially relevant citations were obtained and saved as Adobe-PDF files that were linked to the Access database. Whenever it was uncertain as to whether a citation was appropriate, the full-text copy was obtained. After the first reviewer screened the database, the citations that were deemed ineligible were excluded. If uncertain as whether to include an article, the article in question was reviewed again until a final decision was made.

3.2.2 Data abstraction

A single reviewer (K) abstracted data from all eligible full-text citations using an electronic data abstraction app.

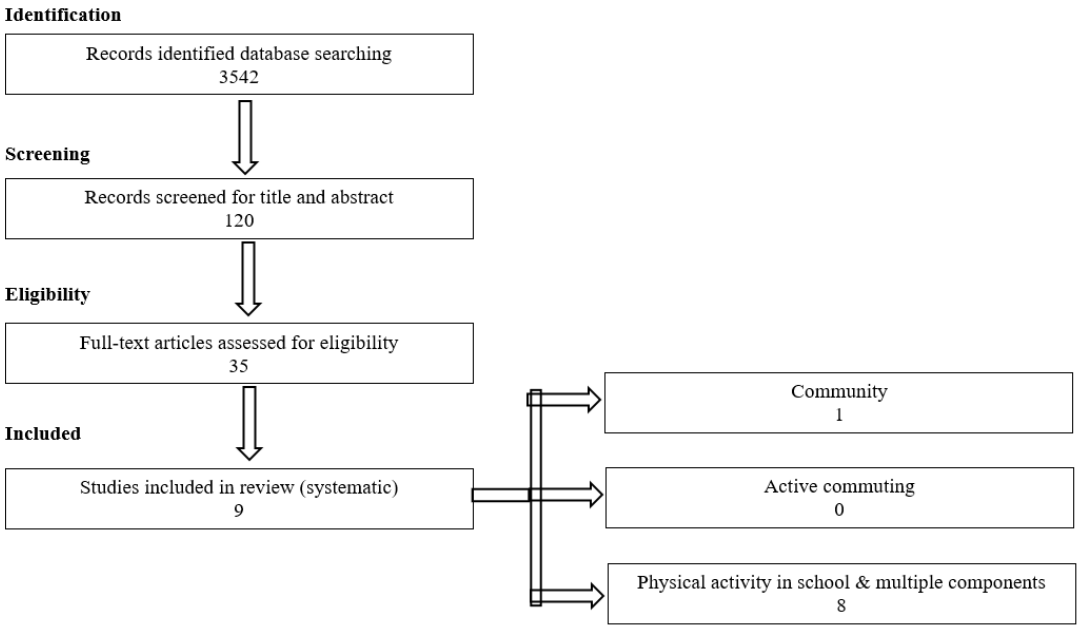

Table 1. Identification of Included Studies

4 RESULTS

The reviews included CT or (cluster)-RCTs with the goal of PA promotion in adolescents reporting a baseline and at least one follow-up measure of PA and/or fitness. Almost all the studies included focused on the school system. While the upper range of age included was generally 18–19 years, the lower range of age was 10 to 12 years. A description of the reviews and their conclusions is provided below.

The PRISMA flow diagram of included studies is presented in Fig. 1. Initial searches identified 3542 articles, 120 were selected based on title and abstract review and 35 was selected based on full text articles assessed for eligibility. Eighty-five articles were excluded based on title or abstract review and the full text of 35 articles were assessed for final inclusion. Nine were identified as meeting all eligibility criteria and were included in the narrative synthesis. Studies were excluded based on review of full text because they did not present an intervention, did not report promotion of PA as primary outcomes, were not accessible, or made diet an intervention. Some other studies were excluded because it presented data on families where adults and children were included in the same analysis. Adult interventions were not an explicit exclusion criterion; however, the unique focus of this intervention and its narrower target population was considered during synthesis and interpretation of the results.

4.1. Population & Community characteristics

The studies included are based in different continents, Four from Europe (Three from United Kingdom, One from Netherlands), Two from America (One United State, One Ecuador), One from Australia, One from Taiwan, and One from Iran. The studies represented here involves adolescents of all group category. The studies involve both male and female although Two were exclusively only female participants. The population size of the studies ranged between 78 and 25000.

4.2. Intervention characteristics

The included interventions are diverse, although all of them are school based, but they have different approach. The study ranged from four weeks to twenty-eight months. Three of the intervention in this study are based on theoretical models while six of them are multicomponent approach which involved the use of objective measures. Five made use of Pedometer or Accelerometer and one made use of wearable technology (FITBIT). All the programs were designed with the goal of promoting and improving PA.

Of the Nine intervention studies, three were focused on behavioral change developed based on social learning theory while the other six are focused on effect of the intervention on Physical activities (i.e. Vertical jump (Andrade et al.,2014), Aerobic steps (Lee et al.,2011), Daily step (Schofield et al., 2005). In these programs, there were follow-up after the intervention of 12-weeks (Lee et al., 2011) and 6 months (Taymoori et al., 2007)

4.3. Physical activity and fitness outcomes

Five of Nine studies relied on Objective measures of PA. Of the Five studies, one employed the use of objective measure only at the follow-up phase while the other four made use of the objective measure during the intervention phase. One study combined curricular materials, staff development, and on-site follow-up.

Andrade et al. (2014) reported increase in vertical jump, and reduction in time to speed shuttle run. However, there was limitation in the measurement of PA in a subsample. Similarly, Lee et al. (2011), reported an improvement in aerobic steps among adolescent girls. Provision of leaflet can be a cost-effective means for promoting physical activity among adolescents (Hill et al., 2007)

Pedometer use in low-active adolescents can improve PA. There was little consistency in the definition of physical activity or PA intensity, as one study reported intervention to increase daily step (McKenzie et al., 2004). It was also reported that application of healthy lifestyle technology may cause reduction in motivation to PA (Kerner et al., 2017).

Table 2: PHYSICAL ACTIVITY GUIDELINES IN SOME COUNTRIES

Organization or country	Year	Age (years)	Guidelines
Australia	2014	13-17	• At least 60minutes of MVPA everyday • Young people's physical activity should include a variety of aerobic activities • On at least three days per week, young people should engage in activities that strengthens muscles and bones • To achieve additional health benefit, young people should engage in more activity
Canada	2010	12-17	• At least 60 minutes of MVPA daily, this should include; • Vigorous-intensity activities at least three days per week • Activities that strengthens muscles and bones at least three days per week
European Union	2008	School Age	• School aged youth should participate in 60 minutes or more of moderate to vigorous physical activity developmentally appropriate, enjoyable, and involve a variety of activities
New Zealand	2010	5-18	• Throughout each day, • Do 60 minutes or more of MVPA • Be active in as many ways as possible, for example, through play, cultural activities from place to place • Be active with friends and family
United Kingdom	2010	5-18	• All children and young people should engage in moderate to vigorous intensity physical activity from 30 minutes to several hours every day • Vigorous intensity activities, including those that strengthen muscles and bones every week
United States	2008	6-17	• 60 minutes(1Hour) or more of Physical Activity daily • Aerobic most of the 60 minutes or more minutes a day should be either moderate or vigorous intensity • Vigorous intensity Physical activity at least three days a week • Muscle and bone strengthening as part of this 60 or more minutes of daily physical activity • Muscles and bones strengthening physical activity on at least three days of the week
World Health Organization	2020	5-17	• At least 60 minutes of MVPA daily, mostly aerobic, physical activity, across the week • Vigorous-intensity aerobic activities, as well as those that strengthen muscles and bones, at least three times per week • Adolescents should limit the amount of time spent being sedentary, particularly the amount of recreational screen time.

PA provides multiple-related benefits in adolescents (WHO, 2010). However, 81% of adolescents are physically inactive across the globe (Guthold et al., 2020). Physical inactivity poses grave threat to the health and wellbeing of the adolescents and the population at large (Ekelund et al., 2019; Lee et al., 2012). This has prompted implementation of policies and programs to increase the level of PA in the adolescent population thereby giving room for creation of PA guidelines by different countries and, by the WHO (Guthold et al., 2018) as presented in table 1. These recommendations are relevant to all children and adolescents, unless specific medical conditions indicate to the contrary, irrespective of sex, race, ethnicity, or income level (WHO, 2019).

Table 3: Physical activity intervention in adolescents with impacts

AUTHOR	COUNTRY/JOURNAL TITLE	SAMPLE NO/GENDER/ AGE	DESIGN OF THE STUDY	STUDY DURATION	OUTCOME/RESULT	CONCLUSION	RECOMMENDATION
Andrade et al.,2014	International Journal of Behavior, Nutrition and Physical Activity. Ecuador	N=1440 Boys/Girls 12-15 yo	Cluster Randomized pair matched Trial	28 months	Intervention increased vertical jump. The proportion of student who met the recommendation for PA increased in intervention school	A school-based intervention with an individual and environment component can improve physical fitness and can minimize the decline in PA levels	
Mckenzie et al., 2004	Epidemiology USA	N=25000 Boys/Girls 6-8th grade	Randomized Trial	2 years	Increased Moderate to vigorous Physical Activity	A sustained and realistic intervention can increase student's physical activity	There is need to place higher priority on encouraging young people to be physically active daily and provide program and environment that make it easy to be active
Taymoori et al., 2007	International journal of behavioral Nutrition and Physical activity Iran	N=161 14 years Girls	Randomized controlled trial	6 months	Effective at follow up. Increased PA in the HP group compared to the control group	Multicomponent means of increasing PA among adolescent girls is better	
Hill et al., 2007	Social Science and Medicine UK	N= 503 Boys/Girls 16-21years	Randomized Control Trial	4 weeks	Significant increase reported Exercise and Intention to exercise	Intervention effects were assessed 3 weeks post-intervention	The leaflet can be a cost-effective means for promoting exercise among youth in college setting
Lee et al., 2011	Journal of Clinical Nursing Taiwan	N=94 Girls X age= 16	Experimental Design	12 weeks with follow up	Increase in Aerobic steps	A 12-week intervention designed on theoretical foundation of self-efficacy theory and provision of pedometer was found to have an effect on increasing physical activity of adolescent girls	Health professionals involved in the care of adolescent health should provide physical activity intervention combining self-efficacy theory and provision of pedometer to promote physical activity
Lubans et al., 2006	Journal of Exercise Psychology UK	N=78 16-18 years Boys/Girls	Randomized Controlled Trial	10 weeks	Increased Physical Activity in intervention group	The result of the study provide evidence that PA intervention can be implemented in the final years of high school and the program need not be intensive and time consuming to be effective on a short-term basis	
Schofield et al., 2005	Medicine and Science in Sports and Exercise Australia	N=85 Girls 15-16	Quasi-experimental control design	12 weeks	There is significant increase in total physical activity in intervention group with PED(Pedometer)	The use of pedometers and daily step count result in short-term enhanced PA	PA improvement can be observed if the period of intervention is extended to >12weeks

Slootmaker et al., 2010	Preventive Medicine The Netherlands	N=87 Boys/Girls X Age=15.1	Randomized control Trial	3 months	In girls, the intervention group had increased in Moderate PA. In boys, the intervention group showed a relative reduction in sedentary time compared with the control group	There is a promoting intervention effects on MPA among girls and sedentary time among boys	Developing a better tailored advice, which targets boys and girls separately to improve the feasibility and attractiveness of such an intervention
Kerner et al., 2017	American Journal of Health Education United Kingdom	N = 84 Boys/Girls 13-14 years	Mixed Method sequential design	8weeks	Quantitative findings identified significant reductions in satisfaction and autonomous motivation and significant increases in a motivation after 8 weeks. Qualitative evidence suggested short-term increases in motivation through feelings of competition guilt and internal pressure	Finding suggest that healthy lifestyle technology may have negative motivational consequences	It is recommended that certified health education specialists should support young people to personalize health targets in order to critically engage the normalized health targets.

4.4. Intervention Characteristics

The characteristics of interventions to improve PA in adolescents varies with type, setting and target groups. Intervention type can be educational, environmental policy and could be a multicomponent approach. In this study, multicomponent and educational intervention types were included. Setting is very important aspect of promoting PA in adolescents, and in this study, all the included interventions are school-based setting and this is no surprise because most adolescents attend school and the best place for easy access to adolescents is the school. The target groups included in this study are male and female. However, there are more studies that involved both groups in their study than single sex. As represented in table 4.

Table 4. Summary of interventions to improve physical activity in adolescents, stratified by setting, characteristics of intervention, and target group

Variables	Adolescents (9 studies)
Intervention type	No. of studies
Educational	3
Environmental Policy	0
Multicomponent	6
Setting	
School	8
School plus community or family	1
Family	0
Community	0
Primary Care	0
Target group	
Male	0
Female	2
Both gender	7

4.5. Health professional, Medical doctor Engagement

All included studies reported engagement with relevant stakeholders (i.e students, teachers, health workers) as part of intervention module. Engagement activities included semi-structured interviews (Kerner & Victoria, 2017), focus groups (Lubans et al., 2006). (Andrade et al., 2014) indicated a participatory research process involving Medical doctors, and health professionals, in the design and implementation of the study. It is unclear if any of the interventions or programming was maintained.

5. DISCUSSION

The study by Hill et al. (2007) reported an experimental test of the effectiveness of an exercise-promotion leaflet based on the Theory of planned behavior (TPB). Also, the Elaboration Likelihood Model (Leaflet-Quiz condition) and theory describing implementation intention formation (Leaflet-Implementation Intention condition) which are cognitive prompts were tested for their effectiveness on the leaflet. The results show that all three leaflet conditions significantly increased reported exercise, intention, behavioral control, attitudes, and normative beliefs compared to the control condition. Fishbein et al. (2001) have emphasized the importance of environmental barriers/facilitators and behavioral skills when promoting behavior change. Targeting a wider set of determinants of exercise and exercise change may necessitate more than persuasive communication. It was reported by Nichols et al. (2000) that feedback on performance, provision of social support and relapse prevention may all enhance the effectiveness of exercise promotion programs. Nonetheless, the leaflet used increased reported exercise and this effect was greatest for students who had weaker pre-intervention intentions to increase exercise, reported less control over being able to do so and had a less positive attitude towards doing additional exercise. From a public health perspective, this is really encouraging because it suggests that this theory based, low cost intervention had most impact on youth who most need pro-exercise interventions. It was stated that the lack of any difference between the three leaflet conditions was unexpected while stronger effects on exercise with the addition of a motivational incentive and quiz was however expected, as deduced from a similar classroom-based study, Krahe et al. (2012) who found out that a leaflet designed to increase condom use was effective compared to a no-leaflet control only when combined with a motivational incentive and quiz. Surprisingly, there was no strong effect on exercise with the addition of motivational incentive and quiz and this could be attributed to the fact that sample of the college students in the study possibly needed less motivational incentive than younger students reading about safer sex. It could also be that the time period for the study may have curtailed the effect of the motivational incentive.

In the study by Andrade et al. (2014) reporting positive effect on fitness parameters achieved by a school-based intervention and giving recommendations for moderate to vigorous activity of adolescents in an urban area of Ecuador. There was an increase in muscular strength as measured by vertical jump corresponding to 10% of the average score at baseline in the intervention group. Ortega et al. (2008) have shown that higher muscular strength during adolescence is associated with better cardiovascular and skeletal health at adulthood. There was also an improvement of the speed shuttle run with intervention and this corresponds to a relative time decrease of 3% compared to the

baseline values. However marginally insignificant, the effect is considerable and compares to differences in speed-agility between nonobese and obese adolescents (Deforche et al., 2003). There was a surprising outcome with regards the effect on the balance component of physical fitness which unexpectedly was more pronounced in the control group. This could be attributed to the fact that the intervention promoted physical activity and did not include specialized training for static activities needed for the balance test (DiStefano et al., 2009). It was also observed that adolescents in the control group engaged more in static games during breaks like hacky sack and throwing coins near a target, while those in the intervention group were encouraged to engage in sports and use the walking trail. It was also noted that participants used more time for the speed shuttle run when getting older in both the intervention and control group. This tendency contradicts the literatures that states that adolescents decrease the time on speed shuttle through the transition from 12 to 15 years (Deforche et al., 2003; Chillon et al., 2011). The explanation of the different findings in Ecuadorian adolescents is speculative and perhaps was due to a less favorable environmental conditions for physical activity (Hallal et al., 2012), differences in tradition of health promotion programs (Dobbins et al., 2013) and genetic factors (Costa et al., 2012; Gonzalez-Andrede et al., 2007). For screen time and sedentary behavior. no intervention effects were found. Screen time in classes was covered only during the first year of the trial, which was possibly not enough to produce a significant effect. Vertical jump on the other hand only improved significantly in school pairs that had both male and female students. PA in adolescents is subjected to peer influence (Maturo et al., 2013). A study reported that PA of male adolescents was associated with that of their female peers, while female PA was associated with PA of their male and female peers (Sirard et al., 2013).

Lee et al. (2011), found that a 12-week SPAA-G underpinned by self-efficacy theory and the provision of a pedometer increases the number of aerobic walking steps. The use of pedometers has become popular in promoting PA through providing daily step monitoring and feedback. Several studies have tested the effectiveness of pedometers in both measuring the amount of PA, specifically ambulatory activity (Cyarto et al., 2004; Lubans et al., 2009; Schneider et al., 2004; Tudor-Locke et al., 2002; Welk et al., 2000) and motivating regular PA (Lubans et al., 2009; Sidman et al., 2004; Speck & Looney 2001; Talbot et al., 2003). A trial by Rooney et al. (2003) assessing the function of wearing a pedometer with pretest and post-test awareness and amount of PA undertaken found that wearing a pedometer is a simple, non-invasive way to increase awareness of daily activity and leads to increased physical activity. Lee et al. (2011), found that students could achieve the advised total number of walking steps simply shaking the pedometer, therefore, the index of aerobic walking was assessed rather than total steps. Although the number of aerobic steps

increased significantly among the intervention group, but the intervention tested in the study was not effective in increasing the proportion of students who meet these guidelines set for number of steps walked. This could be attributed to the time limitation for this study. However, among insufficiently active adolescents, every increase in moderate to vigorous PA may have been important in producing health-related benefits. Effects of the PA intervention in increasing of cardiopulmonary endurance and exercise self-efficacy were not found as well in the study. It is suggested that future study is needed to test those effects when the intervention period is extended. Additionally, because this intervention program was conducted in a college, it may be that the intervention would not have the same effect when tested in other schools with different environments. Further work would be warranted to examine the effect of SPAA-G on promoting PA in other schools and in different contexts.

The primary objective of this study by Lubans et al. (2006), was to examine the effects of the Lifetime Activity Program on adolescent PA behavior. Although the effect size was small, the intervention group reported spending 78 minutes more activity per week on average at the end of the intervention, compared to the control group. In addition to short-term changes in MVPA, students in the intervention group reported better exercise self-efficacy and personal PA rating compared to those in the control group. Although some interventions with adolescents and young adults have found statistically significant improvements in MVPA at postintervention (Epstein, Paluch, Gordy, & Dorn, 2000; Leslie, Fotheringham, Veitch, & Owen, 2000; Patrick et al., 2001; Schneider- Jamner et al., 2004; Simon et al., 2004), others have not (Cardinal, Jacques, & Levy, 2002; Fardy et al., 1996; Goldfine & Nahas, 1993; Saelens et al., 2002). Furthermore, some PA intervention reviews identifies the failure of most studies to include follow-ups (Hillsdon, Foster, & Thorogood, 2005; Reilly & McDowell, 2003; Timperio, Salmon & Ball, 2004) to determine whether behavior change was Sustained. Those that have included longer-term follow-ups often find that group differences no longer exist (Calfas et al., 2000; Deforche, De Bourdeaudhuij, Tanghe, Hills, & De Bode, 2004). Project Active Teens (Dale & Corbin, 2000; Dale, Corbin, & Cuddihy, 1998) provides evidence for the long-term effectiveness of PA interventions in the senior school years. Unfortunately, the results from Project Active Teens should be treated with caution as the study involved a quasi-experimental design, with the comparison group consisting of students who had transferred to the school after the intervention had been implemented. In the study by Lubans et al. (2006), the activity levels of the intervention group were sustained at the three-month follow-up. However, the control group, had also increased their PA levels and there was no longer a statistically significant difference between the two groups. One possible explanation for this result

is that the week in which the follow-up took place did not represent a normal school week, as the students had finished class and were preparing for exams. In addition, the final assessment took place in the summer, a time when students are often more active (Booth et al., 2002; Rifas-Shiman et al., 2001). Considering evidence from previous studies examining the seasonality of PA and the findings by Lubans et al. (2006), it was suggested that the winter months are an ideal time for intervention with the adolescent age group. It was also recommended that school-based PA promotion programs should be suitable for the school environment and designed to be implemented by physical education (PE) teachers. It has also been proven that PA interventions can be implemented among adolescents and that programs need not be intensive and time consuming to be effective on a short-term basis.

Mckenzie et al. (2004) reported that a staff development program increased PA in middle-school PE without requiring increases in class frequency or duration. An 18% increase in PA during PE classes was attained without hiring new teachers or taking more time away from other curricular areas. play, free play, and management. At baseline, the proportion of class time MVPA was less than the 50% recommended in Healthy People 2010 (Healthy People, 2010). Overall, it was reported that students in intervention group were in MVPA about 52% of lesson time, whereas those in control schools were in MVPA about 48% of the lesson. Thus, the type of intervention developed for M-SPAN can assist in achieving increased time for the practice of physical skills and game tactics and help meet health objectives. At year 2, intervention students spent an average of 2.6 more minute in MVPA per PE lesson than controls (i.e., 13 $min \cdot wk^{-1}$). Without scientific proof, it appeared teachers needed to go through a process of change that required them to understand, accept, and implement new concepts and teaching methods before they became habitual. It also took time for teachers to become comfortable with consultants, implement even small changes in school policies, and become fully engaged in adopting a health-related approach to PE. The adopted changes included both managerial (e.g., incorporating PA during the taking of roll) and curricular decisions (e.g., considering that providing PA was more important than talking about the history of a sport). A disappointing finding was that the PA increase for girls was not statistically significant. This occurred despite the vast majority of PE classes being coeducational, permitting boys and girls to be exposed to the same teaching methods in the same classes, this disagrees with the finding of U.S. Department of Health and Human Service (2000) This result suggests additional intervention strategies may be needed for girls, such as including activities more preferred by girls, single-sex activities, and different motivational and instructional techniques. Another disappointment was that the SOFIT instrument did not assess teacher’s behavior elaborately. PE was typically conducted in

large, outdoor, noisy settings, and often it was difficult for observers to hear teachers. The M-SPAN study appears to be the first evaluation of a health-related PE intervention for middle schools (reference). Strengths included 2 years of systematic intervention, use of direct observation for assessing primary outcomes, collection of process data, and use of the school as unit of randomization, intervention, and analysis. The study was large, encompassing 24 middle schools with diverse ethnic and socio-demographic characteristics and over 25,000 students per year. The size enhances generalizability, though a restriction to Southern California is a limitation that needs to be overcome by evaluating similar interventions in different regions. It has established a fact that a sustained and realistic intervention can increase the physical activity of adolescents.

Schofield et al. (2005) carried out a study and reported on the effects of a Controlled Pedometer-Intervention for Low-Active Adolescent Girls. The significant differences between the pedometer (PED) and minute (MIN) groups at the mid-intervention time point, coupled with the significant time interaction suggest that greater increases in accumulated PA was observed with daily step count targets than time-based prescription. However, because of non-significant differences in the MIN and the PED group at the postintervention time point, it can be deduced that the PED may not be superior to MIN beyond an initial 6-week period. This may suggest that interventions of longer duration may be necessary to sustain the effect observed at 6week, or that both PED and MIN will elicit similar long-term results in PA in adolescent girls. The PED intervention group in this 12-week study had a mean increase in average daily steps of approximately 2747 steps per day. This is consistent with other pedometer-driven trials in adult populations i.e., the First Step Program, a 16-week intervention for adults with type 2 diabetes, reported increases of approximately 4230 steps per day (Lauzon et al., 2008). Sugiura et al. (2002) demonstrated increases (based on a 2-yr trial) of approximately 2500 steps per day when using middle-aged women as the participants.

Slootmaker et al. (2010) reported the result of their study in adolescents showing that in girls, the intervention was effective in improving MPA with the intervention group reporting 411 minutes more MPA compared to the control group after 3 months but this effect washed out after 8 months. Among boys, it was observed that there was a reduction in time spent being sedentary in the intervention group at 8month follow-up compared to an increase in the control group. This intervention was set up as a minimal intervention, to make it easily applicable in real-life settings. However, the frequency of wearing the PAM and visiting the PAM COACH website was disappointing. This low degree of exposure of the participants to the intervention may largely explain the limited intervention effect. Also, there was different intervention effects in subgroups of

gender. In girls there was effect on MPA and in boys on sedentary behavior. This may be explained by differences in preferences. Since girls were less active at baseline, they may have been more motivated to become physically active in increasing their time spent on MPA rather than reducing their sedentary behavior or increase their time playing sports. At baseline, boys were already sufficiently active and reported a relatively high number of minutes being sedentary. Therefore, it may have been easier for them to reduce their sedentary behavior rather than to further increase their PA. Daily PA and its determinants was assessed by self-report. It is general knowledge that self-reported PA is prone to misreporting therefore, the results should be interpreted with caution. However, intervention was successful in increasing MPA and decreasing sedentary behavior given the fair reproducibility and low validity of the AQuAA. Conclusion should be carefully reached about the magnitude of the effects. It was also reported that 90% of the boys and 67% of the girls already met the PA guideline at baseline bearing in mind that the study focused on inactive adolescents. This may explain the differential effect in boys and girls. Since girls were less active at baseline, they may have been more motivated to become physically active. Also attitude and self-efficacy scores towards PA at baseline were relatively high, and thus difficult to improve. Therefore, for most of the participants the necessity to become physically more active may not have been obvious (Slootmaker et al., 2009). It was also observed that the practical advice given on the website was partly based on the objectively monitored PAM score. Accelerometers worn at the hip are insensitive to certain types of movements, specifically non-ambulatory physical activities with arm and or limb movements, such as cycling and rowing (Slootmaker et al., 2009; Trost et al., 2005). This limitation of the accelerometer may have declined the accuracy of the advice given at the PAM COACH, particularly for subjects who cycle a lot, which is a common mode of transport among adolescents in the country where the study was carried out (Ministry of Transport, 2007). Although activities that are not accurately measured by the PAM can be included by hand on the PAM COACH, a study has shown that recipients of negative or unexpected feedback responded by doubting the accuracy and credibility of the feedback information (Bowen et al, 2013). This phenomenon may have discouraged the participants in uploading the PAM data. It was suggested that, future research could focus on designing a system that provides accurate and credible activity feedback to users, which may lead to better compliance. Furthermore, the power of the was lowered because analyses for gender was separated because of effect modification. few visits to the website and the high dropout during the intervention suggest that the present PAM intervention is not very attractive to apparently healthy adolescents. It was proposed that developing a better-tailored PA advice, which targets boys and girls separately to improve the feasibility and attractiveness of an

intervention is important. This should be evaluated in a larger population using both objective as well as subjective measures of PA.

A randomized controlled trial conducted by Taymoori et al. (2007) to compare the effectiveness of two individually tailored PA interventions (HP and THP) for adolescent Iranian girls reported that, following the intervention adolescents in both intervention groups had greater progression through stages of change and more PA compared to individuals in the control group. Furthermore, this finding is in consonant with studies that found that level of PA increased as individuals moved to a higher stage of change (Berry et al., 2005; De Bourdeadhuji et al., 2004; Marshall et al., 2001; Wood et al., 2002). At the end of intervention period the participants in the intervention groups reported spending about one hour more in activity per day compared to participants in the control group who increased their activity by only six minutes per day compared to baseline. This finding is likely related to the overall advancement into action stages by participants in both intervention groups because a number of other studies have found that participants in the action stages reported more PA than those are in the pre-action stages (Berry et al., 2005; De Bourdeadhuji et al., 2004; Marshall et al., 2001; Wood et al., 2002). While there were no significant differences between the THP and HP groups, or between the HP and control groups for PA at follow-up, a statistically significant difference was found between the THP and control group in daily minutes of PA. This indication of sustained activity in the THP group may be due to the increased use of behavioral processes by these participants. Another explanation for this finding may be that the THP group reported fewer barriers and more social support for PA than the HP and control groups. The cultural norms for Iranian females to be active are restrictive. Therefore, it may be that by asking the participants' teachers and mothers to encourage the participants to be more active and to express their expectations that the girls be more active, a shift occurred around social norms for the participants within the study. However, it also may be that changes occurred due to peer learning, so, further research is required to clarify this finding. However, this is an extremely encouraging finding in general, that can be used when creating interventions with similar populations.

Kerner et al. (2017) explored whether wearable healthy lifestyle technologies impacted on adolescents motivation for physical activity and it was reported that there was unexpectedly reduced motivation to promoting physical activity in adolescents, this could be due the fact that participants may become fatigued with wearing the wearables and may not be wearing it all the time and this could affect the outcome. This reason is supported by the report of a study by Lubans et al. (2012) whereby there was no effect on physical activity level of participants after a post intervention test

was done with the use of an accelerometer. However, there have been various reports with regards to the positive effect of wearables on PA levels of adolescents. Shimon et al. (2009) reported a positive impact on PA of 13 years old adolescents after a 5-weeks intervention with the use of pedometer. In agreement with this, Lubans et al. (2009) also reported an increase in daily steps of adolescents. A study by Vasickova et al. (2013) reported an increase in PA levels among 15-16years adolescents who had a PA intervention with the use of a combination pedometer and step dairies. The use of wearables may be important in promoting the PA levels of adolescents but there is paucity of studies whereby the wearables are used alone in promoting the PA levels of the adolescents.

Limitation

The strength of this review includes the capturing of all the age categories of adolescents. Secondly, the review demonstrates the effectiveness of physical activity intervention in adolescents. However, this review is not without limitations. Firstly, there were perhaps other interventions with better designs but are not included in this review because they didn’t meet the inclusion criteria. It is also to be said that as this review is only based on manuscripts, it is hard to draw a picture of how the components of these interventions were conducted and implemented. Furthermore, most of the reviewed studies were conducted in diverse SES groups, but analyses stratified by SES were not done which can make it difficult to generalize the outcome since it has been established that adolescents in low SES are less active and also, are less likely to be involved in PA. Therefore, it is recommended that future researchers should consider the SES in their intervention. Also, it is recommended that research into family and community-based intervention is required for generalisation of these interventions.

6. CONCLUSION

From the studies reviewed, it was observed that interventions to improve the PA of adolescents do have positive impact, however, a well-tailored intervention is required for gender specificity. Also, multicomponent approach involving the family, teachers and health professionals is more valid. It has also been established that short term interventions only have short term effects and are not sustained for long. Perhaps, to achieve significant changes and improvement in PA among adolescents, interventions among adolescents should last longer than 3 months (Neumark et al., 2003). While some interventions with adolescents have found statistically significant improvements in PA behavior following shorter interventions (Lubans et al., 2006; Schofield et al., 2005) the long-term sustainability of behavior in these interventions remains unproven.

7. SUMMARY

Engaging in PA has been established to prevent variety of disease. Adolescence is a period between childhood and adulthood, and it is a very important phase in the development of an individual. Over 70% of adolescents both males and females do not meet the physical activity recommendation guideline. This paper highlights the PA interventions that has been used to promote PA among adolescents over the last two decades. A systematic review of articles dealing with adolescents and PA interventions were sorted from different databases. All the interventions were school-based but with different approaches i.e. Educational, Theoretical, and mixed-component approaches. It was concluded that these interventions promoted the physical activity of adolescents. However, it has short term effects if intervention were to be for short period. Therefore, it was suggested that the intervention to promote PA among adolescents should be sustained for over a longer period in order to achieve long term effects.

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