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Physical Activity and Lifestyle: Association with Cardiovascular Risk Factors in Pediatric Ages

Physical Activity and Obesity in Preschool Children

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Palavras-chave: OVERWEIGHT; OBESITY; PHYSICAL ACTIVITY; PRESCHOOL.

Para a Filipa

Para o Filipe

Para os meus Pais

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Resumo

A prevalência de excesso de peso e obesidade, a adopção de comportamentos altamente sedentários bem com a falta de actividade física (AF) em crianças tornou-se num grande problema de saúde pública. Estes são importantes factores de risco para o aparecimento de muitas doenças crónicas e estão associados com estilos de vida e factores ambientais. Dada a crescente preocupação geral com os níveis da saúde das populações futuras, as escolas foram identificadas como potencialmente promotoras de comportamentos saudáveis uma vez que as crianças dispendem uma grande quantidade do seu tempo em meio escolar.

O objectivo da presente tese foi estudar a prevalência de excesso de peso e obesidade, a análise dos padrões de AF e a compreensão da associação entre estes padrões de AF e a obesidade.

Methods:

O Indice de Massa Corporal foi calculado: peso sobre o quadrado da altura (kg/m^2).

A AF foi medida por acelerometria.

Results:

A prevalência de excesso de peso/obesidade foi de 33,1%. A prevalência de sobrepeso/obesidade foi significativamente ($p<0.05$) superior nas raparigas (37.2%) do que nos rapazes (29,6%). O tempo despendido em actividades físicas moderadas a vigorosas (AFMV) foi significativamente superior ($p<0.001$) quando foram usados intervalos de tempo de 5 segundos em comparação com os de de 60 segundos, independentemente do género. Além disso, foi encontrada uma diferença nas AFMV de aproximadamente 17 minutos entre os 2 intervalos de tempo. Apesar de 83% do tempo diário ser despendido em comportamento sedentário, a maioria dos pré-escolares atingiram as recomendações de AF e de AFMV durante a semana. Durante o dia com aula de educação física as crianças tiveram mais tempo em AF total e AFMV comparativamente com a média dos restantes dias ($p<0.05$). Em ambos os sexos, a aula de educação física contribui em média 27,7% da AF total e 32,8% da AFMV, durante o dia de aula de educação física. O modelo da regressão logística múltipla ajustado para o índice de massa corporal no primeiro e segundo ano de idade e outros potenciais confundidores mostrou que as crianças com uma actividade física vigorosa baixa (tertil mais baixo) tinham uma maior probabilidade de serem classificadas com tendo excesso de peso comparativamente com as que apresentavam uma actividade física vigorosa elevada (tertil mais elevado)(OR= 4.4; 95%CI: 1.4-13.4; p= 0.008).

Conclusão:

Apesar da baixa idade dos sujeitos que compõem o nosso estudo, os valores encontrados são alarmantes e pedem intervenções apropriadas; o uso de intervalos de tempo de 5 segundos poderá ser melhor adaptado aos padrões de AF das crianças pré-escolares; em estudos futuros deverá ser considerada independentemente o comportamento sedentário e a AF, uma vez que estes nem sempre se podem anular; a AF estruturada como a aula de educação física aumentou o nível de AF total diária e a AFMV; a AF vigorosa pode desempenhar um papel importante na no crescimento da prevalência de excesso de peso e obesidade desde a idade pré-escolar.

Estudos longitudinais e de intervenção são necessários para clarificar esta tendência ao longo dos anos.

PALAVRAS-CHAVE: SOBREPESO, OBESIDADE, ACTIVIDADE FÍSICA, EDUCAÇÃO FÍSICA, PRÉ-ESCOLAR

Abstract

The prevalence of overweight and obesity, highly sedentary behavior (SB) and a lack of physical activity (PA) among young children have become a major public problem. They are important risk factors for many chronic diseases and are associated with several lifestyles and environmental factors. Starting from the general concern about the future generations´ health, schools have been found to be potentially main settings to promote positive health behavior, since all children can be reached spending large amounts of time in the school environment.

The overall aim of the present thesis was to study the prevalence of overweight and obesity, analyze patterns of PA and understand the association between PA patterns and obesity.

Methods:

Body mass index (BMI) was calculated as weight/height squared (kg/m^2). Physical Activity was measured by accelerometer.

Results:

The overall prevalence of overweight/obesity was 33.1%. The prevalence of overweight/obesity was significantly ($p<0.05$) higher in girls (37.2%) than boys (29.6%). The time spent in moderate-to-vigorous physical activity (MVPA) was significantly higher ($p<0.001$) when a 5-s epoch was considered compared to the 60-s epoch, regardless gender. Further, it was found a difference of ~17 minutes difference between the 2 epoch systems for moderate-to-vigorous physical activity (MVPA). Despite 83% of time during the day being spent in sedentary behavior; most preschool children met the daily physical activity and MVPA recommendations on weekdays. During the day with physical education class, preschool children engaged significantly more in Total PA (TPA) and MVPA than during the average of other days ($p<0.05$). Physical Education class contributed, on average, 27.7% for the TPA and 32.8% of MVPA during the day with physical education class in both gender. Multiple logistic regression model, adjusted for BMI at first and second years of life and other potential confounders showed that children with low vigorous-PA were more likely to be classified as OW compared to those with high vigorous-PA (OR= 4.4; 95%CI: 1.4-13.4; p= 0.008).

Conclusion:

Despite the early ages under study, the values found in our study are alarming and call for appropriate interventions; using a 5-s epoch might be better adapted to the preschooler's activity pattern; in future research should consider the two constructs of sedentary behavior and physical activity independently, as they might not necessarily counteract each other; structured physical activity such as a PE class increased the daily TPA and MVPA level of pre-school children; Vigorous PA may play a key role in the obesity development already at pre-school age.

Longitudinal and interventional studies are needed in order to clarify this tends over time.

KEY-WORDS: OVERWEIGHT; OBESITY; PHYSICAL ACTIVITY; PHYSICAL EDUCATION; PRESCHOOL;

Resumé

La prévalence du surpoids et de l'obésité, bien comme l'adoption de comportements sédentaires (CS) et l'absence d'activité physique (AP) chez les jeunes enfants sont devenus un problème de santé publique. Ceux-ci sont des importants facteurs de risque de nombreuses maladies chroniques et sont associés aux modes de vie et aux facteurs environnementaux. En raison de l'augmentation de la préoccupation sur la santé des générations futures, les écoles ont été identifiées comme l'un des principaux vecteurs de promotion de comportements positifs sur la santé, puisque les enfants passent beaucoup de temps en milieu scolaire.
L'objectif général de cette thèse fut étudier la prévalence du surpoids et de l'obésité, analyser les modèles AP et de comprendre l'association entre les modèles AP et l'obésité.

Méthodes

L'indice de masse corporelle (IMC) a été calculé en fonction de la masse/taille au carré (kg/m^2). L'accéléromètre a été utilisé pour mesurer l'activité physique.

Résultats

La prévalence de surpoids/obésité a été de 33,1%. La prévalence de surpoids/obésité a été significativement ($p < 0,05$) plus élevé chez les filles (37,2%) que chez les garçons (29,6%). Le temps consacré à l'activité physique d'intensité modérée à vigoureuse (APMV) a été significativement plus élevée ($p < 0,001$) lorsqu'il a été utilisé des intervalles de temps de 5 seconde comparativement aux intervalles de 60 seconde, indépendamment du sexe. De plus, une différence alentour de 17 minutes pour l'APMV a été constatée entre les deux intervalles de temps. Malgré 83% du temps dépensé pendant la journée être consacré à des comportements sédentaires, la plupart des enfants d'âge préscolaire ont atteint les recommandations d'activité physique et APMV pendant les jours de la semaine. Pendant la journée avec les cours d'éducation physique les enfants se sont engager beaucoup plus en AP total (APT) et APMV en comparaison à la moyenne des autres jours ($p < 0,05$). Chez les deux sexes, les cours d'éducation physique ont contribué, en moyenne, 27,7% de l'APT et 32,8% de l'APMV, pendant la journée avec les cours d'éducation physique. Le modèle de régression logistique multiple ajusté pour l'indice de masse corporelle dans les première et deuxième années et d'autres potentiels facteurs de confusion ont montré que les enfants aient une faible AP vigoureuse (tercile plus bas) ont été plus susceptibles d'être classifiés comme aient du surpoids au contraire de ceux qui avait une haute AP vigoureuse (tercile plus élevé) (OR 4,4 =; IC 95%: 1,4 à 13,4, $p = 0,008$)

Conclusion

Malgré le jeune âge des sujets qui composent notre étude, les résultats obtenues sont alarmants, et clame des interventions appropriées; l'utilisation d'intervalle de temps de 5 seconde peut-être mieux adaptés à l'activité d'âge préscolaire; à l'avenir la recherche devrait examiner les concepts de comportement sédentaires et d'activité physique de façon indépendante, car elles ne s'annule pas nécessairement; l'activité physique structuré, comme les cours d'éducation physique, a augmenté le niveau d'ATP quotidienne et le niveau de APMV; AP vigoureuse peut jouer un rôle important dans la croissance de la prévalence du surpoids et de l'obésité déjà a l'âge préscolaire.
Des études longitudinales et interventionnelles sont nécessaires afin de clarifier cette tendance au fil du temps.

Mots-clés: SURPOID; OBÉSITÉ; ACTIVITÉ PHYSIQUE; ÉDUCATION PHYSIQUE; PRÉSCOLAIRE

Indice

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Lista de Abreviaturas:

PRESTYLE – Preschool Physical Activity, Body Composition and Lifestyle Study
BMI – Body Mass Index
OV/OB – Overweight/Obesity
IOTF – International Obesity Task Force
NOW – Non-Overweight
OW - Overweight
PA – Physical Activity
SB – Sedentary Behaviour
TPA – Total Physical Activity
MPA – Moderate Physical Activity
VPA - Vigorous Physical Activity
MVPA – Moderate and Vigorous Physical Activity
cpm – Counts per Minute
PE – Physical Education
GLM – General Linear Model
OR – Odds Ratio
SES – Socio-Economic status
WHO – World Health Organization

1. Introduction and Background

1. Introduction and Background

Physical inactivity is associated with increased risk of several chronic diseases (Hussey et al., 2007). In adults, it was observed that each 1-MET increase in exercise capacity conferred a 12% improvement in survival (Myers et al., 2002). It has been suggested that inactivity during youth is linked to several health-related risks in adulthood (Guo et al., 2002, Dietz, 2004). Furthermore, it is widely believed that reduced physical activity (PA) and/or the increase sedentary behaviour are implicated in the aetiology of childhood obesity (Troiano and Flegal, 1998, Reilly et al., 1999).

Cardiovascular disease (CVD) is usually not diagnosed until adulthood, however atheroma injury has been found during the first and second decades of life in children and young adults (Strong and Mc, 1962, Strong et al., 2001). Signs of atherosclerosis in youth have been associated with CVD risk factors such as obesity, abnormal plasma lipoprotein levels, elevated blood pressure, and insulin resistance (Zieske et al., 2002, Tracy et al., 1995). Longitudinal studies have further indicated that measures of BMI, total cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and blood pressure taken during childhood and adolescence track into adulthood and predict adult values (Dietz, 1998a, Raitakari et al., 2003, Li et al., 2004, Li et al., 2003).

In this context it is necessary to understand the early natural history of arteriosclerosis so that preventive measures can be instituted early in life.

One important risk factor for CVD is obesity (Eckel and Krauss, 1998). The prevalence of paediatric obesity has increased dramatically in the last decades,

in most countries (Nowicka and Flodmark, 2008, Pate and O'Neill, 2008), as well as in Portugal (Padez et al., 2005, Sardinha et al., 2010). Some studies have described overweight and obesity prevalence among preschool children and pointed-out that those are characterized by high levels (Kremer et al., 2006, Maffeis et al., 2006, Moschonis et al., 2008). All of these investigations had reported that approximately more than one quarter of children aged 2-5 years are overweight or obese

This trend is particularly alarming owing to the increasing risk of multiple medical comorbidities (Freedman et al., 2001b, Miller et al., 2004, Freedman et al., 1999, Berenson et al., 1998, Gutin et al., 1990, Shear et al., 1987, Valente et al., 2001, Thompson and Wolf, 2001) such as higher levels of blood pressure, type 2 diabetes **i**ncreased risk of cardiovascular disease (CVD) risk factors early in life (Teixeira et al., 2001, Ribeiro et al., 2003). Moreover, over the long term, childhood/adolescence overweight is strongly associated with adult obesity (Guo et al., 2002, Dietz, 2004, Mo-suwan et al., 1998). Research showed that as early as 3 years of age, obese children have elevated levels of inflammatory markers that have been linked to heart disease which manifests itself later in life.

Human obesity is a multi-factorial disorder where both genes (Thorleifsson et al., 2009) and lifestyle factors (environment and behavior), including diet, physical activity (PA) (Janz et al., 2002, Trost et al., 2003, Loos and Rankinen, 2005, Strong et al., 2005) and TV viewing (Dennison et al., 2002, Lumeng et al., 2006, Jackson et al., 2009) are important contributors. It has also been shown that both maternal and paternal body mass index (BMI) have a strong influence

on offspring's risk of obesity (Gordon-Larsen et al., 2000, Labayen et al., 2010, Wardle et al., 2001, Berkowitz et al., 2005). Likewise, birth weight and weight gain that occur during the first years of life have been reported as determinants of childhood obesity (Reilly et al., 2005, Olson, 2008, Goodell et al., 2009). For instance, an association was found between birth weight and the risk of being obese in children at the age of 4, 8, 10 and 12 years (Maffeis et al., 1994) and a very high risk of obesity that began at age 2 persisting through to age 5 (Yin et al., 2009).

Besides the previously mentioned factors, there exist other potentially modifiable factors in intrauterine life, infancy and the preschool period that increase the risk of overweight in childhood and adolescence. These include, among others, excessive gestational weight gain (Moreira et al., 2007, Oken et al., 2007), maternal smoking during pregnancy (Oken et al., 2005, Olson, 2008, Gorog et al., 2009), reduced breastfeeding duration (Harder et al., 2005, Reilly et al., 2005, Gillman et al., 2008) and short sleep duration (Reilly et al., 2005, Taveras et al., 2008, Tian et al., 2010).

Preschool period, around the time of the adiposity or BMI (Daniels, 2006), was considered as a possible critical period for obesity development during in which the long term regulation of energy balance may be programmed (Dietz, 1997). Adiposity rebound (AR) refers to the increase in BMI that occurs after a nadir observed in children around the age of 5 to 6 years (Rolland-Cachera et al., 1984). Numerous studies have shown that children displaying an early AR are at an increased risk for adult obesity (Rolland-Cachera et al., 1987,

Freedman et al., 2001a, Whitaker et al., 1998) or type 2 diabetes (Eriksson et al., 2003) compared with those who undergo AR at a later age.

Usually, BMI (weight (kg)/height* height (m^2)) is a simple and convenient proxy measure, which has been used to track obesity in children owing to a significant association between BMI and body fat mass. Indeed consistent evidences showed that a high BMI for age in paediatrics has an acceptable diagnostic accuracy for a high body fat content, and denotes increased risk of morbidity (Reilly, 2006).

Considering these facts of a childhood obesity epidemic, the importance of sedentary behaviour (SB) and PA for this age group is receiving considerable attention. However, SB and PA are only modestly correlated, having other socio-demographic determinants and are associated differently to health risk factors (Biddle et al., 2004, Brodersen et al., 2005) Some studies show that time spent in SB is not associated with time spent in PA (Ekelund et al., 2006, Lioret et al., 2007, Vandewater et al., 2007, Marshall et al., 2002), others say that these two variables are inversely related (Koezuka et al., 2006, Zabinski et al., 2007) or the type of activities like TV viewing or using the computer can have different values in relation to PA (Santos, 2005). Others studies still recognized that SB is distinct from PA (Spanier et al., 2006, Biddle et al., 2004).

Sedentary behavior refers to activity in which the work of the large skeletal muscles involved in habitual movement and postural control is very limited. Sitting is the most prevalent SB (Hamilton MT e tal., 2007).

Sedentary behaviour is now considered the biggest modifiable problem of Public Health (Raitakari et al., 1997, Strong et al., 2005, Hussey et al., 2007,

Pate and O'Neill, 2008), perhaps the major risk factors for the onset of many chronic degenerative diseases (Hussey et al., 2007) not only since there is evidence of tracking to adulthood (Twisk et al., 1997, Guo et al., 2002, Dietz, 2004, Telama et al., 2005, Yang et al., 2006), but it also appears that PA levels fall throughout childhood (Salmon et al., 2005) from childhood to adolescence and adulthood, which appear to have an impact on adult health (Dietz, 1998b). In fact, SB has become more common among younger generations (Biddle, 2007) and may be positively associated with overweight and obesity in children and adolescents (Ekelund et al., 2006, Lioret et al., 2007, Goran et al., 1999). Furthermore, several studies have shown that pre-school children spent the majority of their daily time engaged in sedentary /light activities (Kelly et al., 2005, Fisher et al., 2005) and like adults, children have also adopted sedentary lifestyles during their leisure time, such as, increased time spent playing with computers, TV,viewing, playing video games or listening to music (Dennison et al., 2002). For instance, the American Academy of Pediatrics has published recommendations aimed at reducing the hours of low activity energy expenditure such as watching television to a maximum of 2 hours on average per day (AAP, 2001).

Although the time spent with computers and watching television is not systematically and negatively associated with physical inactivity, use of free time (especially in the period after school and at weekends), in passive or sedentary activities is significant since it seems to decrease their involvement in physical activities (Mota and Sallis, 2002).

On the other hand, researchers begin to explore the PA dose-response relationship with health parameters, as it is increasingly important to provide a more precise estimate of both quantity and quality of PA (Sallis and Saelens, 2000). For instance, Trost et al. (2000) highlighted two main goals that justify why precise measures of habitual PA are necessary: (1) to document the frequency and distribution of PA in defined population groups, and (2) to determine the amount or dose of PA required to influence specific health parameters.

Nevertheless, the assessment of PA in childhood is a complex task, hampered by methodological difficulties in which quality measures play a critical role (Freedson et al., 1998, Anderson et al., 2005). This is even more difficult in young children. Indeed, either Reilly et al. (2004) or Kelly et al. (Kelly et al., 2005, Kelly et al., 2006) found that preschoolers are characterized by low levels of PA. Hence, the measurement of PA since early ages is a key factor in lifestyle evaluation and a tool for its control. Previous studies of PA in young children have been limited by the lack of acceptable PA measures. It is well known that young children are unable to self-report their PA accurately (Sirard and Pate, 2001, Ness et al., 2007), and surrogate reports by parents and other adults have limited validity (Sallis and Saelens, 2000).

Recent reviews have shown that accelerometers provide an objective, practical, accurate and reliable means of quantifying the amount and intensity of habitual PA in preschool children (Jackson et al., 2003, Pate et al., 2006). Objective measures, like accelerometers, with real time data storage capabilities offer a distinct advantage over self-report methods and provide

reliable information on PA patterns within a given time period or over several days (Trost et al., 2000).

However, in young children (pre-schoolers) two points have been consider with regard to accelerometers: cut-off points and epochs used. Specific cut-off points for accelerometer data have been designed for young children aged 3 to 5 years old (Reilly et al., 2003, Sirard et al., 2005, Pate et al., 2006). Some studies found different conclusions about prevalence estimates have been reached depending upon the cut-off criterion selected to distinguish moderate-to-vigorous physical activity (MVPA) (Anderson et al., 2005, Mota, 2008); In relation of epoch choices, differences on PA intensity estimates have already described in youth (Nilsson et al., 2002) and in children aged 5- 6 years old (Reilly et al., 2008) depending on epoch selected.

One characteristic across the preschool age group is the typically involuntary, sporadic and intermittent PA. Preschoolers are the most active segment of our population, but this activity is infrequently done for a continuous period of time. Normally, young children's physical activity consists of short bursts of MVPA interspersed by periods of lower intensity activity (such as walking) or resting (Bailey et al., 1995). Capturing the largely unstructured and intermittent physical activity of this age group, such during play time, most accumulated which is challenging but essential for accurate reporting, and accelerometers are well suited for this task.

Therefore, the discrepancy might lie on methodological issues, namely cut-points used and epoch length choice seems to be an important issue when prevalence rates are addressed even in such young ages as kindergarten

children. Indeed, to what extent children meet the recommended guidelines are an opportune topic with public health interest, because there is a risk of misinterpretation depending the factors mentioned above.

Thus, comparing PA values based on physical activity recommendations in pre-school children it is not an easy task.

Although some information has been provided with regard to the associations between physical activity and health parameters in early infancy (Maffeis et al., 1994, Janz et al., 2002, Saakslahti et al., 2004, Reilly et al., 2005), but little is known about the compliance with PA recommendations in pre-school children.

Meanwhile, current health-related PA guidelines suggested that preschool children should accumulate at least 120 minutes of PA per day (60 minutes daily of structured and 60 minutes daily of unstructured physical activity) for a healthy lifestyle (NASPE, 2002). More recently, an expert panel reviewed the literature on PA in school-aged children and recommended that children should participate in at least 60 minutes of MVPA per day every day (Strong et al., 2005).

Although SB (by definition, low activity energy expenditure), fits the classic definition of PA "any bodily movement produced by contraction of skeletal muscle resulting in energy expenditure" (Caspersen 1985), it represents a different kind of behavior, meaning not simply the absence of activity of mild or moderate intensity. Therefore, attention should be paid to these two constructs - sedentary behavior and physical activity - independently for a correct

interpretation of the results found at this age because these two behaviors, SB and PA, might not necessarily counteract each other.

With regard to improving health and welfare, PA has a huge potential (WHO, 2006) and should be recognized as a fundamental public health component and major factor of a healthy lifestyle (WHO, 2007). So, there is a need to understand the factors that influence PA in preschoolers and to learn how to help them to be more active.

Some studies in children and adolescents have described daily patterns of PA, describing differences between defined time blocks within days (Trost et al., 2002, Mota et al., 2003). Although, in some countries, most PA for children occur outside the school environment (Sallis et al., 1993), schools have long been recognized as key settings to promote and to contribute to PA guidelines because children spend a large amount of their day in school (Iverson et al., 1985, Pate and O'Neill, 2008).

Physical Education Class (PE) is recognized as the most widely available tool for promoting PA among children (Sallis and McKenzie, 1991) as well as improving knowledge and attitudes towards PA and development of a disposition for regular activity throughout life (Goodway and Branta, 2003). PE is a requisite part of the preschool curriculum in most of the European countries and can be controlled in terms of its quality and quantity. Moreover, PE is the only form of PA undertaken by almost all children and has the potential to make significant contributions to the general education and development of young people in many ways (Bailey, 2006). In particular the promotion and development of a healthy and active lifestyle is recognised as one of the main

objectives of PE. PE represented a good opportunity for children to accumulate PA and give an adequate amount of PA each day.

Although, limited attention has been given to preschool children PE activities at school, as well as to the contribution of kindergarten school PE to the overall daily Total Physical Activity (TPA) and Moderate-to- Vigorous Physical Activity (MVPA) participation. Thus, it seems necessary to study how schools, and in particular PE classes, can most effectively make a worthy contribution to promote an active and healthy lifestyle.

Given the growing concerns over the harmful effects of sedentary lifestyles on the health of preschoolers, targeted efforts to promote PA seem to be justified. In this respect, early learning experiences are crucial to continuing the involvement in PA. Despite this concern, to the best of our knowledge, there exist few international studies and no data in the preschool age group are available for the Portuguese population.

Thus, the aim of the present thesis was to study the prevalence of overweight and obesity, analyze patterns of PA and understand the association between PA patterns and obesity.

2. Aims

2. Aims

This thesis presents five distinct papers, each based on specifics aims:

Paper I - Vale S.; Santos, R.; Soares-Miranda, L.; Rego, C.; Moreira P.; Mota J. **Prevalence of Overweight/Obesity among Portuguese Preschoolers.** *Archives of Exercise in Health and Disease. In Press.*

(i) to report the prevalence of overweight and obesity (OV+OB) in a sample of Portuguese preschoolers

Paper II - Vale S.; Santos, R.; Soares-Miranda, L.; Silva P.; Mota J. **Preschool children physical activity measurement: importance of epoch length choice.** *Pediatric Exercise Science.* 2009 Nov 21, 413-420.

(i) to document the gender differences in Moderate to Vigorous Physical Activity (MVPA) according to two epoch systems (5 vs. 60 seconds) in preschoolers,
(ii) to document the differences in physical activity (PA) patterns according to two different epoch choices

Paper III - Vale S.; Silva P.; Santos, R.; Soares-Miranda, L.; Mota J. **Compliance with Physical Activity Guidelines in Preschool Children.** *Journal of Sport Sciences***.** 2010 April 28(6), 601-608.

(i) to document the gender differences in physical activity: total physical activity and moderate to vigorous physical activity according to weekdays and weekend and gender in preschoolers
(ii) to document the compliance with physical activity recommendations for total physical activity (*National Association for Sport and Physical Education* guidelines) and moderate to vigorous physical activity during weekday and weekend and between genders

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Paper IV – Vale S.; Santos, R.; Soares-Miranda, L.; Silva P.; Mota J. **The importance of Physical Education Classes in Preschool Children.** *Journal of Paediatrics and Child Health***.** *In Press.*

(i) to analyze differences in total physical activity and moderate to vigorous physical activity of preschool children during daily school hours when they attended the physical education class compared school days without physical education class
(ii) to assess the contribution of physical education classes to the total physical activity in school hours

Paper V – Vale S.; Santos, R.; Soares-Miranda, L.; Moreira, C.; Ruiz, J.J.; Mota J. **Objectively measured physical activity and body mass index in pre-school children** *(review after revision)*

(i) to analyze the association between objectively measured PA and BMI in Portuguese preschoolers

3. Methods

3. Methods

3.1. Study Design and Sampling

This study derived from the Preschool Physical Activity, Body Composition and Lifestyle Study (PRESTYLE), a longitudinal study that started in the fall of 2008.

A random sample of 650 children, aged from 2 to 6 years old, was recruited from kindergartens located in the Metropolitan area of Porto, in Portugal.

Informed written consent was obtained from the children's parents or guardians and school principals. Study procedures were approved by the Portuguese Foundation for Science and Technology and by the Scientific Board of Physical Activity and Health PhD program.

The participants, healthy Portuguese preschool children, were evaluated during school day by trained teachers. The basic characteristics of the participants and the variables examined in each sub-study are presented in the Table 1.

3.2. Anthropometric Measures

Body weight and body height were determined by standard anthropometric methods.

Body mass was measured to the nearest 0.1Kg, with participants lightly dressed (underwear and t-shirt) using a portable digital beam scale (Tanita Inner Scan BC 532).

Height was measured to the nearest millimetre in bare or stocking feet with the participants standing upright against a portable stadiometer (Holtain).

The measurements were repeated twice and the average was recorded.

Body mass index (BMI) was calculated as weight/height squared (kg/m^2). Children were categorized as underweight (Cole, Flegal et al. 2007), non-

overweight, overweight or obese (Cole et al., 2000) following the International Obesity Task Force (IOTF) – proposed gender and age specific BMI cut-off-points (In Paper I). Children were also classified as either non-overweight (NOW) or overweight (OW) according to the sex-adjusted BMI z-score (<1 and ≥1, respectively) (In Paper V).

Table 1: Summary of the characteristics of the sub-studies

Study	Number of Subjects	Age	Variables Studied
I. Prevalence of overweight/obesity among Portuguese preschoolers	625	3-6 years	BMI SES
II. Preschool children physical activity measurement: importance of epoch length choice	59	2-5 years	Physical Activity
III. Compliance with physical activity guidelines in preschool children	245	3-6 years	Physical Activity: - weekdays *vs* weekend - recommendations
IV. The importance of physical education classes in preschool children.	193	3-5 years	Physical Activity Physical Education Classes
V. Objectively measured physical activity and body mass index in pre-school children	281	4-6 years	BMI Physical Activity Potential Confounders

BMI – Body Mass Index

3.3. Physical Activity

Daily PA was measured using Actigraph accelerometer, model GTM1 (Pensacola, FL 32502. USA). This is a small, lightweight, uniaxial device. This accelerometer produces 'raw' output in activity counts per minute (cpm), which gives information about the total amount of physical activity (Janz 1994). The accelerometer output can be interpreted using age specific cut-points, which describe different intensities of PA. Data reduction, cleaning, and analyses of accelerometer data were performed using a specially written program (MAHUffe; available at www.mrc-epid.cam.ac.uk), described elsewhere (Nilsson et al., 2008, Sardinha et al., 2008). Data were analysed using specific paediatric cut-points, which have been validated for young children: Sedentary - ≤1204

cpm ≤1452 cpm ≤1592 cpm; Light PA - >1205 cpm >1453 cpm >1593 cpm; MVPA - ≥2457 cpm ≥3245 cpm. ≥3561 cpm for 3, 4 and 5 years old, respectively and recommended by Sirard et al (2005); ≥1100 cpm for active time recommended by Reilly et al (2003); >1680 cpm for moderate physical activity, and >3360 cpm for vigorous physical activity (VPA) as suggested by Pate et al (2006).

For the purpose of this study the epoch duration or sampling period was set to 5 seconds, which seems to be more accurate and suitable concerning to the spontaneous and intermittent activities of the children.

Table 2 describes the different methods applied in the different papers.

Table 2: Summary of the characteristics of the sub-studies

	Number of days monitoring	**Minimum of hours/day**	**Who place and remove accelerometer**
Paper II Paper IV	5 weekdays	6 hours	Teacher
Paper III Paper V	7 days (5 weekdays and 2 weekends)	10 hours	Parents

The accelerometer was adjusted at the child's right hip by an elastic waist belt under clothing (own cloth and school coat). A data sheet was given to the children's teachers, who were instructed to record the time when the child arrived and leave at school. Activities were not prescribed or directed by the teachers and researchers. Children participated in normal activities in their classmates and home.

The *National Association for Sport and Physical Education* guidelines (2002) were followed for calculating the proportion of children who spent at least ≥120min/day in active play and the proportion who spent ≥60min/day in active play based on Strong et al (2005) and the 2008 US guidelines (for moderate to vigorous physical activity) (In Paper III).

Levels of all PA intensities were defined by PA tertiles, adjusted for sex and age. Children belonging to the first, second and third tertile were defined as low, middle and high PA level, respectively (In Paper V).

3.4. Physical Education Classes

Physical education class formed part of the regular school curriculum and were carried out once a week by a specialized physical education teacher. Each session lasted 50 to 60 minutes and the sessions provided different kind of activities such as ball games, calisthenics, gymnastics and exercises to improve coordination, flexibility and fundamental motor skills (jumping, throwing, etc.…). These activities were not reported by the authors, but each teacher was asked about the class content, which was not modified due to the realization of the study (In Paper IV).

3.5. Lifestyle Variables

Mothers reported the amount of the daily screen time (watching television and/or play videogames) their child spend as well as the daily sleeping time in both week days and weekends. Screen time questions were analyzed as continuous variables (converted to minutes) and also evaluated as a dichotomous variable based on young children recommendation (AAP, 2001). Then, children were classified as accomplished guidelines (watching < 2h/day) and those who did not (watching ≥ 2h/day) (In Paper V).

3.6. Pre and post natal and lifestyle factors

Mothers reported information regarding: gestational weight gain (GWG), maternal smoking during pregnancy (MSP) as well as birth weight and body weight and height during their offspring's at the first and second year of life. GWG was categorized according to Institute of Medicine (1990) as: below, optimal and above GWG, while MSP was categorized as YES or NO (In Paper V).

3.7. Mother BMI

Mothers reported their body weight and height and we calculated BMI was calculated from self-report and used to categorize weight status in three categories according to WHO recommendations (1998), as follows: normal weight (18.5 kg/m^2 ≥ BMI <25 kg/m^2); overweight (25 kg/m^2 ≥ BMI < 30 kg/m^2) and obese (BMI≥30 kg/m^2) (In Paper V).

3.8. Socioeconomic Status

Socioeconomic Status (SES) was defined as the educational level and occupation of the mother (Rundle et al., 2008). The SES was defined based upon Portuguese Educational system a 9 years' education or less- sub secondary level (scored as 1), 10-12 years' education-secondary level (scored as 2) and higher education (scored as 3). Levels 1, 2 and 3 were considered as low, middle and high SES (Mota and Silva, 1999) (In Paper V).

3.9. Statistical Analysis

All statistical analysis were performed using SPSS 15.0 Statistical Program for windows (papers I, II, III and IV) and SPSS 17.0 Statistical Program for windows (paper V). The level of significance for all analysis was set at 0.05.

Table 3 describes the different statistical methods applied in the different papers.

Table 3 – Statistical Methods applied in the different papers.

	Paper I	Paper II	Paper III	Paper IV	Paper V
Two-sided Student's T-test with Bonferroni adjustments	x				
Chi-square test	x		x		x
T-Test independent		x	x	x	
T-Test paired		x			
General Linear Model			x	x	
Multinomial Logistic Regression					x

4. Papers

Paper I

Vale S.; Santos, R.; Soares-Miranda, L.; Rego, C.; Moreira P.; Mota J. **Prevalence of Overweight/Obesity among Portuguese Preschoolers.** *Archives of Exercise in Health and Disease. In Press.*

ARCHIVES of Exercise in Health and Disease

Prevalence of Overweight/Obesity among Portuguese Preschoolers

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Running Title – **Preschoolers` Overweight/Obesity**

Paper I

Abstract

Objectives: The present study aimed to report the prevalence of overweight/obesity in a sample of Portuguese preschoolers. Design: A total of 625 children (males: 53.6%) aged 3 to 6 years-old were included in the study. The International Obesity Task Force (IOTF) cut-offs were used to define overweight and obesity. Main Results: The overall prevalence of overweight/obesity was 33.1%. The prevalence of overweight/obesity was significantly ($p<0.05$) higher in girls (37.2%) than boys (29.6%). Conclusions: Despite the early ages under study, the values found in our study are alarming and call for appropriate interventions.

Key Words: preschool children; body mass index; gender

Introduction

The prevalence of paediatric obesity has increased dramatically in the last decades, in most countries (1, 2), as well as in Portugal (3). This trend is particularly alarming not only for the increasing risk of multiple medical co morbidities (4), but also due to the tendency of childhood overweight and obesity to track into adulthood (5, 6). The increased obesity prevalence in children (7) has increased awareness of obesity as a public health problem (8). The preschool period, around the time of the adiposity or body mass index rebound (9), was considered as possible critical period for obesity development during which the long term regulation of energy balance may be programmed (10). Thus, future interventions might target early life, and focus on environmental changes targeted at relatively short periods in early life, attempting to modify factors early childhood, which are independently related to later risk of obesity (11). Despite this concern, to the best of our knowledge, no data in the preschool age group are available for the Portuguese population. In fact, a recent systematic review found that there was relatively little prevalence data on obesity in young children in Europe, and called for more research on obesity prevalence in this age group (12) Therefore, the aim of this study was to report the prevalence of overweight and obesity (OV+OB) in a sample of Portuguese preschoolers.

Materials and methods

This is a cross-sectional study with a convenience sample carried out in kindergartens from the metropolitan Porto area. The participants were 625

healthy Portuguese preschool children (328 boys) aged 3 - 6 years old ($\overline{X}$ =4.8 ± 1.0 yrs-old). Mean body height was 108.1 ± 8.8 m and mean body weight was 20.1 ± 4.2 kg. Data were collected between January 2008 and January 2009. Participants were evaluated during school day by teachers specially trained for this data collection. Informed written consent was obtained from the children's parents or guardians and school principals. Study procedures were approved by the Portuguese Foundation for Science and Technology and by the Scientific Board of Physical Activity and Health PhD program. The response rate was 96.2%

Body height and body weight were determined by standard anthropometric methods. Height was measured to the nearest millimetre in bare or stocking feet with the participants standing upright against a Holtain portable stadiometer. Body mass was measured to the nearest 0.1Kg, with participants lightly dressed (underwear and tee-shirt) using a portable digital beam scale (Tanita Inner Scan BC 532). The average of two measurements was used for both height and weight.

Body mass index (BMI) was used to define underweight from the references establishing by Cole et al. (13) overweight and obesity defined using the reference established by Cole et al. (14) as recommended by the International Obesity Task Force (IOTF).

Socioeconomic status (SES) defined as the educational level and occupation of the mother, father or by either mother or father (parental education). In this case, Single parent families were also included, and these children were classified according the school education of the single parent The SES was

defined based upon Portuguese Educational system a 9 years' education or less- sub secondary level (scored as 1), 10-12 years' education-secondary level (scored as 2) and higher education (scored as 3). Levels 1, 2 and 3 were considered as low, middle and high SES (15).

Decimal age was calculated as the difference between date of birth and date of the data collection. Each age group was categorized by the midpoint of an age range. For example, the group of children with 4 years old included all the children aged between 3.75 years and 4.24 years, and so forth. Found statistic significant differents

Initially the SES was analyzed, however we didn´t found statist sig differences between different groups of SES and BMI (data not show).

Two-sided Student's T-test with Bonferroni adjustments was used to compare mean values between genders. Chi-Square Test was calculated for BMI categories by gender.

Results

Descriptive characteristics for study participants are outlined in Table 1. Compared to boys, girls were on average younger, heavier, and shorter ($p<0.05$ for all). No statistically significant differences between genders were found for BMI. The prevalence of underweight, overweight and obesity were respectively 2.1%, 27.6% and 9.7% in girls and 3.0%, 20.3% and 93% in boys, ($p>0.05$). The prevalence of OV+OB was 37.2% in girls and 29.6% in boys ($p<0.05$).

Table 1 – Participants' characteristics

	All Group N=625		Girls N=290		Boys N=335		p^a
	mean	SD	mean	SD	mean	SD	
Age (years)	4.8	1.0	4.7	1.0	4.9	1.0	0.014
Body mass (kg)	20.1	4.2	19.6	4.0	20.5	4.2	0.010
Body height (cm)	108.1	8.8	106.8	9.0	109.2	8.4	0.001
BMI (kg/m^2)	17.1	1.8	17.1	1.8	17.0	1.9	0.749
BMI (%)							
Under-weight	2.6%		2.1%		3.0%		0.162
Normal-weight	64.3%		60.7%		67.5%		
Overweight	23.7%		27.6%		20.3%		
Obese	9.4%		9.7%		9.3%		
Non-over	66.9%		62.8%		70.4%		0.042
Overweight+Obese	33.1%		37.2%		29.6%		

BMI – Body Mass Index

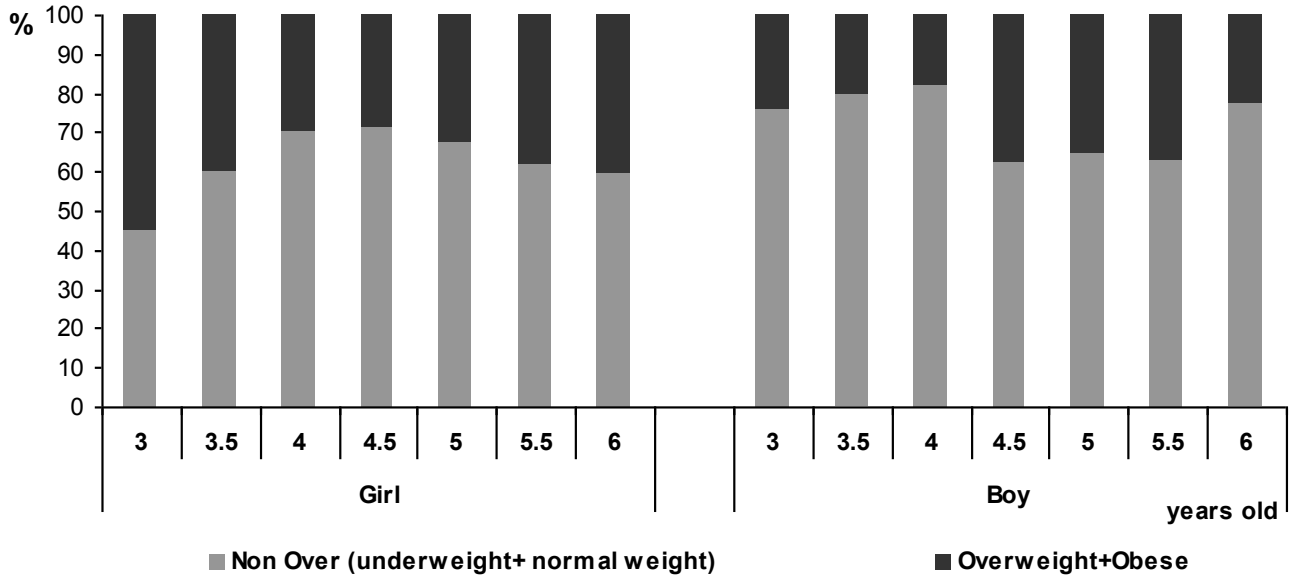
SD – Standard Deviation

Non-over = under + normal weight

[a] – compares mean values between genders with T-Test with Bonferroni adjustments.

Figure 1 shows the prevalence of OV+OB in both genders, according to age. In girls a steady pattern of OV+OB prevalence from 3 until 4.5 years-old was observed, and thereafter the values rise until 6 years-old. In boys, we found similar values between 3 and 4 years-old. Then, the prevalence rates were higher (about 15%) until 5.5 years-old followed by a lower prevalence rate at the age of 6.

Figure 1 - Prevalence of Overweight/Obesity by age in Girls and Boys.



Discussion

This study is the first that describes the prevalence of OV+OB in a sample of Portuguese preschoolers. This is a timely issue because some studies pointed-out that even preschoolers are characterized by high levels of overweight and

obesity (16, 17), and a recent review called for more research on the prevalence of obesity among pre-schoolers (12).

The prevalence estimates of OV+OB found in this Portuguese sample were 37.2% in girls and 29.6% in boys ($p<0.05$). To the best of our knowledge, few studies have described overweight and obesity prevalence among preschool children. Indeed consistent evidences showed that a high BMI for age in paediatrics has acceptable diagnostic accuracy for a high body fat content, and denotes increased risk of morbidity (18). The reasons of this important health problem are not clear, once some studies revealed that not only genetic, but also environmental and behaviour factors are involved in the development of obesity at theses ages (17, 19, 20). Therefore it is worth considering the perinatal parameters and characteristics that protect or predispose children to overweight at different stages during infancy and preschool years (17). Additional reasons that highlight the potential importance of prevention in early childhood include adiposity rebound and the limited potential for reversing metabolic changes associated with obesity in later life (21). The data of our study suggested that girls seem to be at higher risk than boys with regard to overweight and obesity. In addition, there was a suggestion that trends in overweight and obesity with age might differ between boys and girls in this sample: while girls showed higher OV+OB prevalence as they get older (from 4.5 until 6 years-old) boys showed lower prevalence rates for the same age-groups. Given the age-groups analyzed, the high prevalence of overweight and obesity found in our study are alarming and call for appropriate interventions.

Limitations to the present study should be recognized. It was based on a convenience sample and so the generalisability of the prevalence estimates is unclear. However, almost all invited participants actually took part and the very high prevalence of overweight and obesity observed suggests that prevalence of overweight and obesity across Portugal is very high. Future studies of nationally representative samples are needed to clarify prevalence of overweight and obesity in preschool children in Portugal.

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Paper II

Vale S.; Santos, R.; Soares-Miranda, L.; Silva P.; Mota J. **Preschool children physical activity measurement: importance of epoch length choice.** *Pediatric Exercise Science.* 2009 Nov 21, 413-420.

Pediatric Exercise Science, 2009, 21, 413-420

Preschool Children Physical Activity Measurement: Importance of Epoch Length Choice

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The purpose of this study was twofold: first to document the gender differences in Moderate to Vigorous Physical Activity (MVPA) according to two epoch systems (5 vs. 60 s) in preschoolers, and, second to document the differences in physical activity (PA) patterns according to two different epoch choices. The sample comprised 59 preschoolers (31 girls) aged 2–5 years old. PA was assessed by accelerometer during school hours. The time spent in MVPA was significantly higher ($p < .001$) when a 5-s epoch was considered compared to the 60-s epoch, regardless gender. Further, it was found a difference of ?17 min difference between the 2 epoch systems for MVPA. Different epoch times might affect the time spent in MVPA among preschool children.

Physical inactivity is associated with increased risk of several chronic diseases (7). In adults, it was observed that each 1-MET increase in exercise capacity conferred a 12% improvement in survival (13). It has been suggested that inactivity during youth is linked to several health-related risks in adulthood (4,6). Furthermore, it is widely believed that reduced physical activity (PA) and/or the increase sedentary behavior are implicated in the etiology of childhood obesity (20,28).

However, as researchers begin to explore the PA dose-response relationship with health parameters, it is increasingly important to provide a more precise estimate of both quantity and quality of PA (24). For instance, Trost et al. (29) highlighted two main goals that justify why precise measures of habitual PA are necessary (1): to document the frequency and distribution of PA in defined population groups, and (2) to determine the amount or dose of PA required to influence specific health parameters.

Nevertheless, the assessment of PA in childhood and adolescence is a complex task, hampered by methodological difficulties in which quality measures play a critical role (2,5). This is even more difficult in young children. Indeed, either Reilly et al. (21) or Kelly et al. (10,11) found that preschoolers are characterized by low levels of PA and high levels of sedentary behavior. Hence, the

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measurement of PA since early ages is a key factor in lifestyle evaluation and a tool for its control. Previous studies of PA in young children have been limited by the lack of acceptable PA measures. It is well known that young children are unable to self-report their PA accurately (14,26), and surrogate reports by parents and other adults have limited validity (24).

Although objective measures, like accelerometers, with real time data storage capabilities offer a distinct advantage over self-report methods and provide reliable information on PA patterns within a given or over several days (29), two methodological difficulties on estimates prevalence are still inconclusive. First, several age-specific activity thresholds have been suggested for youth with different proposed accelerometer cut points (5,19,27). Secondly, differences on PA intensity estimates according to epoch choices was described in youth (16). However, in young children (preschoolers) these two points have been differently addressed. In fact, while specific cut-off points for accelerometer data have been designed and purposed for young children aged 3 to 5 years old (18,23,27). At best of our knowledge, only one study have attempted to compare the estimates of PA prevalence rates according to two different epoch choices (15s-30s-60s) in preschool children (22) but none used such as lower epoch as 5 s.

Thus, the purpose of this study was twofold: first to document the gender differences in Moderate to Vigorous Physical Activity (MVPA) according to two epoch systems (5 vs. 60 s) in preschoolers, and, second to document the differences in physical activity (PA) patterns according to two different epoch choices.

Methods

Participants and Setting

The participants were 59 healthy Portuguese preschool children (28 boys and 31 girls) aged 2–5 years old ($\bar{X}$ = 4.3 ±1.1 yrs-old). Mean body height was 101.03 ± 9.79 cm and mean body mass was 17.5 ± 3.3 kg. These values were within the normal ranges for children of this age (1,3,11).

Informed written consent was obtained from the children's parents and school principal. Study procedures were approved by the Portuguese Ministry for Science and Technology and by the Ethics Committee of Physical Activity and Health PhD program.

Anthropometry Measurement

Body height and body mass were determined by standard anthropometric methods. Body height was measured to the nearest millimeter in bare or stocking feet with the child standing upright against a Holtain portable stadiometer. Body mass was measured to the nearest 0.1 Kg, using a portable digital beam scale (Tanita Inner Scan BC 532), with the participants in T-shirt and shorts. The average of two measurements was used for both body height and body mass.

Physical Activity Assessment

Daily PA was measured using the MTI/CSA WAM-7164 accelerometers (MTI. Fort Walton Beach. Florida. USA). This is a small, lightweight, uniaxial device.

This accelerometer produces 'raw' output in activity counts per minute (CPM), which gives information about the total amount of physical activity (9). Alternatively, accelerometer output can be interpreted using age specific cut-points, which describe different intensities of PA. Data reduction, cleaning, and analyses of accelerometer data were performed using a specially written program (MAHUffe; available in www.mrc-epid.cam.ac.uk), described and used previously (15,25). Data were analyzed using specific pediatric cut-points, which have been validated for young children (27). The age-specific CPM cut-offs for 3, 4, and 5 years old children with regard the different activity intensities (in CPM) were respectively: Sedentary—≤1204. ≤1452. ≤1592; Light PA—>1205. >1453. >1593; MVPA—≥2457. ≥3245. ≥3561. These cut-points were used and recommended by Sirard et al. (1,27) and Alhassan et al. (1). A specific regression analyses was used to identify cut of points counts for 2 years old: Sedentary—≤1028; Light PA—>1029; MVPA—≥1984 according to recommended specific cut-points (1,27).

For the purpose of this study the epoch duration or sampling period was set at 5 s (5-s) and 60 s (60-s) to detect differences in the intensity rates of the spontaneous activities of the children. To achieve our goal, the monitor was set to 5-s epochs and then the data were reintegrated to 60-s epoch, which was described previously (22).

Protocol

The study was conducted on 5 consecutive school days (Monday to Friday) in February of 2008, during school hours, for a minimum of 6 hr per day. Because once a week each child was engaged in a swimming session, that day was excluded from the analysis because the total monitoring time was less than 6 hr. Therefore, for the purpose of this study only 4 school days were considered. Teachers were instructed to place the accelerometer on the respective child at the arrival at school and remove it before they go home. The accelerometer was firmly adjusted at the child's right hip by an elastic waist belt under clothing (own cloth and school coat). Before test period and for every child, the activity monitors were tested. A data sheet was given to the children's teachers, who were instructed to record the time when the monitor was attached in the morning and detached in the evening. They were also instructed to note every time children performed any activity like swimming, gymnastics, walking, gardening and simply going to the recess. Activities were not prescribed or directed by the teachers and researchers. Children participated in normal activities with their classmates.

Statistical Analysis

All data were checked for normality before statistical analysis. Descriptive statistics were used to characterize and describe the sample. The 5-s epoch and the 60-s epoch were used to determine the number of minutes in the different PA intensities (Moderate PA, Vigorous PA, and MVPA). Prior analysis using independent and paired *T*-test was done to assess differences between gender for PA intensities and anthropometric characteristics and within each gender differences in PA intensities, according to 5 and 60 s epochs. As no statistical significant differences were found, no further gender analysis was performed. Paired T-test analyzed differences in PA

intensities according to 5 and 60 s epochs. Analysis was carried-out with SPSS 15.0 for windows. The level of significance was set at $p < .05$.

Results

Children's descriptive characteristics and MTI raw data were summarized by all group and gender in Table 1.

Figure 1 shows the differences in time spent (min.) in moderate, vigorous and MVPA during school hours period according to the two epoch lengths. As expected, the time spent in all PA intensities were significantly higher ($p < .001$) when a 5-s epoch was considered compared with a 60-s epoch. Given the fact that PA guidelines stressed the engagement in 60 min MVPA daily, it is worthy to notice the ?17 min difference in MVPA between the 2 epochs systems.

Discussion

The aim of this study was to analyze the magnitude of differences in PA intensities using two different epoch lengths in a sample of preschooler's boys and girls. This is a timely issue because some studies pointed-out that even preschoolers are characterized by low PA levels and high levels of sedentary behavior (8,11,21). On the other hand, since children are likely to be engaged in activities that involves bending, jumping, running and throwing as part of their daily PA, measurement tools should be validated for use with such activities (17). Studies carried out with those activities found moderate and significant correlations and researchers concluded that accelerometers are an appropriate instrument for measuring children's free-play PA (19).

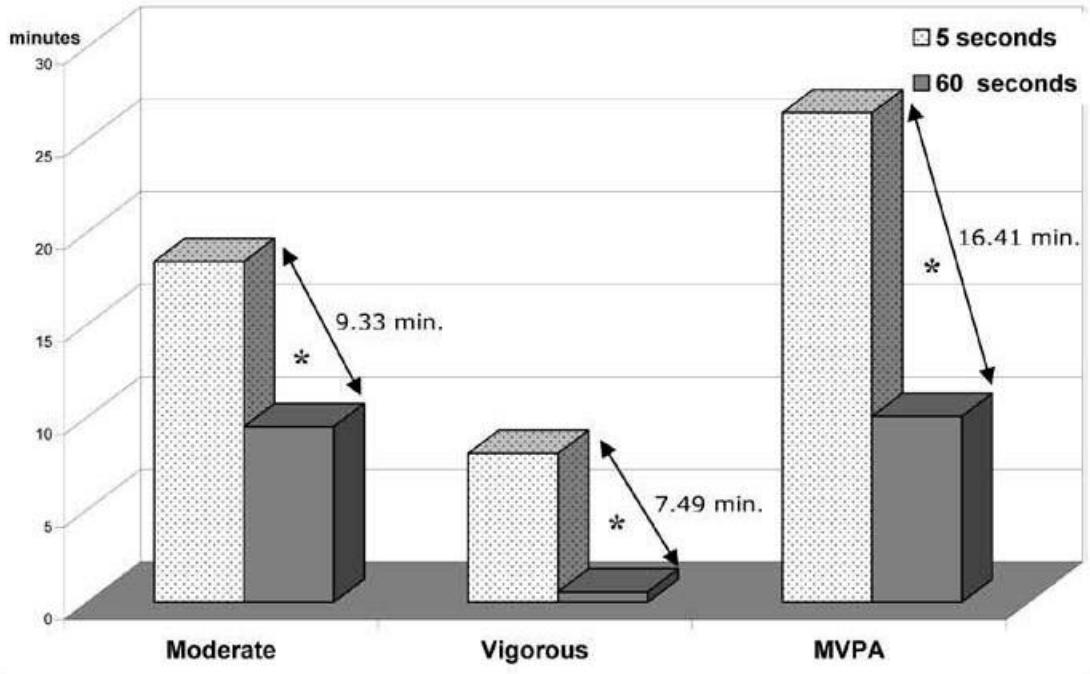

Figure 1 — Average time (min.) spent in different PA intensities according to the two epoch choices in all group. * $p < .001$

Table 1 Descriptive Characteristics of the Sample

		All (n = 59)	Girls (n = 31)	Boys (n = 28)	
Age (years)		**4.26 ± 1.15**	4.35 ± 1.08	4.16 ± 1.23	*NS (0.543)*
Body mass (kg)		**17.50 ± 3.26**	17.39 ± 3.04	17.62 ± 3.55	*NS (0.791)*
Height (cm)		**101.03 ± 9.79**	100.92 ± 9.20	101.16 ± 10.58	*NS (0.926)*
BMI (kg/m^2)		**17.06 ± 1.27**	17.03 ± 1.42	17.08 ± 1.11	*NS (0.879)*
5 s epoch (min.)	Time in Moderate Activities	**18.42 ± 7.03**	17.49 ± 6.43	*NS (0.292)*	
	Time in Vigorous Activities	**8.05 ± 3.80**	7.91 ± 3.67	*NS (0.782)*	
	MVPA	**26.46 ± 9.64**	25.41 ± 9.08	*NS (0.380)*	
60 s epoch (min.)	Time in Moderate Activities	**9.49 ± 8.00**	8.27 ± 6.94	*NS (0.220)*	
	Time in Vigorous Activities	**0.56 ± 0.71**	0.52 ± 0.62	*NS (0.673)*	
	MVPA	**10.05 ± 8.43**	8.79 ± 7.31	*NS (0.230)*	

Note. BMI= body mass index. MVPA = moderate-vigorous physical activity. *NS* = not significant.
All data expressed as mean± *SD*

The main finding of this study was that we found that children showed lower time spent in Moderate PA (9.33 min), Vigorous PA (7.49 min) and MVPA (16.41 min) when 60-s epoch was considered compared with the 5-s epoch. These findings are noteworthy because an estimate of PA prevalence is a public health concern. However, while different conclusions about prevalence estimates have been reached depending upon the cut-off criterion selected to distinguish MVPA (2,12), the importance of the epoch time on prevalence rates are less studied and to the best of our knowledge only one study have attempted to compare the estimates of PA prevalence rates according to different epoch choices in children age 5–6 years old (22).

Our data agree with findings in older children (16), (22) showing that a shorter epoch time is more susceptible to detected higher levels of vigorous physical activity than an higher epoch time (60-s) did. Nonetheless, our data give additional support to those findings because we also found that a shorter epoch time (5-s) showed statistically significantly higher time spent in moderate PA and MVPA. Given the fact that PA guidelines stressed the accomplishment of 60 min of MVPA daily, the difference between the two epoch lengths (~17 min.) corresponds about 28% of the total daily time allocated to guidelines achievement. Thus, the critical point is that different epoch times influences the prevalence of MVPA among preschool children. Therefore, the epoch choice seems to be an important issue when prevalence rates are addressed even in such as young ages as the kindergarten children. Indeed, to what extent children meet the recommended guidelines are a timely issue with public health interest, because there is a risk of misinterpretation depending on epoch times used. Furthermore, these results showed some evidences that 5-s epoch might be more effective to capture PA patterns in these young ages and also suggest that the 5-s epoch might be better adapted to the preschooler's activity pattern.

Limitations to the current study should be recognized. The sample is small and it is believed that a larger group of participants is needed to clarify to what extent the differences are important for public health strategies. Further, studies should be designed to improve such estimations since the validity of activity monitors vary by setting (laboratory or field) and type of activity (30).

Conclusion

Our data showed that different epoch times might affect prevalence rates of the time spent in MVPA among preschool children. The findings suggested that using a shorter epoch might be better adapted to the preschool children PA patterns.

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Paper III

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Compliance with physical activity guidelines in preschool children

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Paper III

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Compliance with physical activity guidelines in preschool children

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Abstract
The aims of this study were (1) to document differences in physical activity (both total and moderate-to-vigorous physical activity) between the sexes on weekdays and weekend days in preschoolers, and (2) to assess compliance with recommendations for total physical activity (National Association for Sport and Physical Education guidelines) and moderate-to-vigorous physical activity on weekdays and weekend days in the same children. The sample comprised 245 preschoolers (105 girls, 140 boys) aged 3.5–6.0 years old. Physical activity was assessed using an Actigraph accelerometer. Data were analysed with specific software and activity was measured as counts per minute. An independent t-test and general linear model with repeated-measures were used to assess differences between the sexes and differences between days (weekdays and weekend days) within each sex, respectively. A chi-square test was used to determine differences between the sexes in the proportion of children complying with physical activity guidelines. In both sexes, sedentary behaviour accounted for the majority of the time on weekdays and weekend days (weekdays: 83%; weekend days: 83.9%). Boys engaged in significantly more ($P < 0.05$) total physical activity and moderate-to-vigorous physical activity than girls (weekdays: boys 155.4 min vs. girls 128.22 min; weekend days: boys 111.2 min vs. girls 90.5 min). On average, preschool children engaged in significantly more ($P < 0.05$) total physical activity and moderate-to-vigorous physical activity on weekdays than weekend days. Altogether, 74.3% and 93.5% of the children met the National Association for Sport and Physical Education guidelines and moderate-to-vigorous physical activity recommendations respectively on weekdays, whereas compliance with both recommendations was substantially less in both sexes on weekend days. The results of this study suggest that despite 83% of time during the day being spent in sedentary behaviour, most preschool children met the daily physical activity and moderate-to-vigorous physical activity recommendations on weekdays. Future research should consider the two constructs of physical activity and sedentary behaviour independently, as they might not necessarily counteract each other.

Keywords: *Accelerometer, preschoolers, physical activity, physical activity recommendations*

Introduction

Children's physical inactivity has been categorized as a modifiable risk factor for lifestyle-related diseases (Andersen, Hasselstrom, Gronfeldt, Hansen, & Karsten, 2004; Hussey, Bell, Bennett, O'Dwyer, & Gormley, 2007; Raitakari et al., 1997; Strong et al., 2005; Teixeira, Sardinha, Going, & Lohman, 2001). Furthermore, it has been suggested that inactivity during youth is linked to several health-related risks in adulthood (Dietz, 2004; Guo, Wu, Chumlea, & Roche, 2002; Telama et al., 2005; Twisk, Kemper, Van Mechelen, & Post, 1997; Yang, Telama, Viikari, & Raitakari, 2006). Moreover, it has been suggested that adequate participation in regular physical activity during childhood might be of critical importance for the prevention of chronic diseases in adulthood (Raitakari et al., 1994; World Health Organization, 2004).

As researchers begin to explore the physical activity dose–response relationship with health parameters, it is increasingly important to provide a more precise estimate of both the quantity and quality of physical activity, namely (1) to document the frequency and distribution of physical activity in defined population groups and (2) to determine the amount or dose of physical activity required to influence specific health parameters (Trost et al., 2002). Hence, the measurement of physical activity at early ages is a key factor in lifestyle evaluation and a tool for its control.

Current health-related physical activity guidelines suggest that preschool children should accumulate at least 120 min of physical activity per day

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(60 min daily of structured and 60 min daily of unstructured physical activity) for a healthy lifestyle (National Association for Sport and Physical Education, 2002). More recently, an expert panel reviewed the literature on physical activity in school-aged children and recommended that children should participate in at least 60 min of moderate-to-vigorous per day each day (Strong et al., 2005).

Although there is some information on the associations between physical activity and health parameters in early infancy (Janz et al., 2002; Maffeis, Micciolo, Must, Zaffanello, & Oinelli, 1994; Reilly et al., 2005; Saakslahti et al., 2004), little is known about preschool children's compliance with physical activity recommendations and, to the best of our knowledge, little information is available on how children behave during weekdays compared with weekend days. This is important, since future strategies for physical activity promotion targeting early childhood should be based on a larger body of evidence from the preschool population.

The aims of this study were (1) to document differences in physical activity (both total and moderate-to-vigorous physical activity) between the sexes on weekdays and weekend days in preschoolers, and (2) to assess compliance with recommendations for total physical activity and moderate-to-vigorous physical activity on weekdays and weekend days in the same children.

Materials and methods

Participants and setting

The participants were part of the Preschool Physical Activity, Body Composition and Lifestyle Study (PRESTYLE), a longitudinal study that began in autumn 2008. A random sample of 650 children, aged 2–6 years, were recruited from kindergartens located in the metropolitan area of Porto, in Portugal. The present study only included children aged 3.5–6.0 years, who wore an accelerometer for at least 4 days (3 weekdays + 1 weekend day). The final sample included 245 healthy preschool children (105 girls, 140 boys; mean $\pm$ *s*: age 5.2 $\pm$ 0.8 years; height 1.12 $\pm$ 0.07 m; body mass 21.6 $\pm$ 4.1 kg). Informed written consent was obtained from the children's parents or guardians and the school principal. The Portuguese Foundation for Science and Technology and the Ethics committee of the PhD programme in Physical Activity and Health hosted by the Faculty of Sports at Porto University approved the procedures.

Physical activity

Daily physical activity was measured by an Actigraph accelerometer, model GTM1 (Pensacola, FL 32502. USA). This is a small, lightweight, uniaxial device. This accelerometer produces "raw" output as activity counts per minute, which provides information about the total amount of physical activity (Janz, 1994). Alternatively, accelerometer output can be interpreted using specific cut-points, which describe different intensities of physical activity. Data reduction, cleaning, and analyses of accelerometer data were performed using a specially written program described and used previously (Purslow, Hill, Saxton, Corder, & Wardle, 2008; Sardinha, Baptista, & Ekelund, 2008). Data were analysed using specific paediatric cut-points, which have been validated for young children: <1100 counts per minute for sedentary time recommended by Reilly et al. (2003), ≥ 1100 counts per minute for active time recommended by Reilly et al. (2003), >1680 counts per minute for moderate physical activity and >3360 counts per minute for vigorous physical activity per minute suggested by Pate and colleagues (Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006).

For the purpose of this study, the epoch duration or sampling period was set to 5 s, which is better and more accurate for the spontaneous and intermittent activities of children as used previously with a similar sample (Vale, Santos, Soares-Miranda, Silva, & Mota, 2009).

The study was conducted on seven consecutive days (Monday to Sunday) between February 2008 and May 2009 to account for seasonal variation. A minimum of 10 hours of data per day was required for analysis. Parents were instructed to attach the accelerometer when the child awoke and to remove it when they went to bed. The accelerometer was firmly adjusted at the child's right hip by an elastic waist belt under their school clothing. A data sheet was given to the children's teachers, who were instructed to record the time when each child arrived at and left school. Activities were not prescribed or directed by the teachers and researchers. Children participated in normal activities with their classmates.

For total activity, we followed the guidelines of the National Association for Sport and Physical Education (2002), calculating the proportion of children who spent ≥ 120 min per day in active play. For moderate-to-vigorous physical activity, we calculated the proportion of children who spent ≥ 60 min per day in active play based on Strong et al. (2005) and the 2008 US guidelines.

Statistical analysis

All data were checked for normality before statistical analysis. Descriptive statistics were used to characterize and describe the sample. The time spent each day in moderate-to-vigorous physical activity was calculated

by summing the minutes of moderate-to-vigorous physical activity for each day. To examine the patterns of physical activity, data were separated into weekdays and weekend days. We first assessed the association between the different variables under study (total physical activity and moderate-to-vigorous physical activity) and the different days of monitoring ($5+2=79.6\%$, $5+1=7.8\%$, $4+2=6.9\%$, $4+1=2.4\%$, $3+2=1.6\%$, $3+1=1.6\%$) and found no statistically significant association between days in the two variables under study. Therefore, for the data analyses we used the average of three weekdays and either one weekend day or the average of two weekend days as indicators of physical activity for weekdays and weekend days respectively. Gender differences in total physical activity and moderate-to-vigorous physical activity between weekdays and weekend days were tested with an independent samples *t*-test. A general linear model with repeated measures was used to examine differences in total physical activity and moderate-to-vigorous physical activity between weekdays and weekend days within each sex and the interaction between the sexes. A chi-square test was used to determine differences between the sexes in the proportion of children complying with physical activity guidelines. All statistical analysis was performed using SPSS 15.0 for Windows. Statistical significance was set at $P < 0.05$.

Results

Table I summarizes physical activity patterns during weekdays and weekend days. On average, boys undertook significantly more ($P < 0.05$) total physical activity than girls on weekdays (boys 155.4 min vs. girls 128.22 min) and on weekend days (boys 131.5 min vs. girls 113.9 min). Boys also spent significantly more time in moderate-to-vigorous physical activity than girls on weekdays (boys 111.2 min vs. girls 90.5 min) and on weekend days (boys 95.4 min vs. girls 79.2 min). Furthermore, irrespective of gender, preschool children engaged significantly more in total physical activity and moderate-to-vigorous physical activity on weekdays (143.7 min and 102.3 min respectively) than on weekend days (123.9 min and 88.4 min respectively).

Table I shows that, for both boys and girls, sedentary behaviour accounted for most time on weekdays (girls 84.7% girls vs. boys 81.6%; $P < 0.05$ for gender) and weekend days (girls 85.3% vs. boys 82.8%; $P < 0.05$ for gender). Both sexes spent more time engaged in moderate-to-vigorous physical activity on weekdays than weekend days (girls 10.8% and 10.2% respectively, $P=0.019$; boys 13.2% and 12.5% respectively, $P=0.019$).

Figure 1 shows the proportion of boys and girls who met physical activity guidelines: (1) the National Association for Sport and Physical Education (NASPE) guidelines for active play ($\geq$120 min per day) and (2) the recommendations for moderate-to-vigorous physical activity ($\geq$60 min per day) on both weekdays and weekend days. Altogether, 74.3% of the children (59% girls and 85.6% boys; $P < 0.05$) met the NASPE guidelines on weekdays, but only 59.2% on weekend days (52.4% girls and 64.3% boys). There was a statistically significant difference in physical activity levels between boys and girls on weekdays and weekend days ($P=0.000$). In contrast, 93.5% of the children (89.4% girls and 96.4% boys; $P < 0.05$) achieved the recommended amount of moderate-to-vigorous physical activity on weekdays, although only 77.6% did so on weekend days (69.5% girls and 83.6% boys; $P=0.009$).

Table I. Physical activity patterns on weekdays and weekend days in boys and girls.

		Combined (N=245)		Girls (n=105)		Boys (n=140)	
		mean	*s*	mean	*s*	mean	*s*
Total physical activity (min)	weekday	143.8	43.3	128.2[a,b]	34.8	155.4[a,b]	45.4
	weekend day	123.9	41.8	113.9[a,b]	33.6	131.5[a,b]	45.7
Moderate-to-vigorous physical activity (min)	weekday	102.3	31.2	90.5[a,b]	27.0	111.2[a,b]	31.3
	weekend day	88.4	33.7	79.2[a,b]	25.6	95.4[a,b]	37.2
Sedentary behaviour (%)	weekday	83.0		84.7		81.6[c]	
	weekend day	83.9		85.3		82.8[c]	
Total physical activity (%)	weekday	17.1		15.3		18.4[c]	
	weekend day	16.1		14.7		17.2[c]	
Moderate-to-vigorous physical activity (%)	weekday	12.1		10.8		13.2	
	weekend day	11.5		10.2		12.5	

[a]Difference between the sexes within weekdays and weekend days ($P < 0.001$).
[b]Differences in physical activity patterns between weekdays and weekend days within each sex ($P < 0.001$).
[c]Differences in physical activity patterns between weekdays and weekend days within each sex ($P < 0.005$).

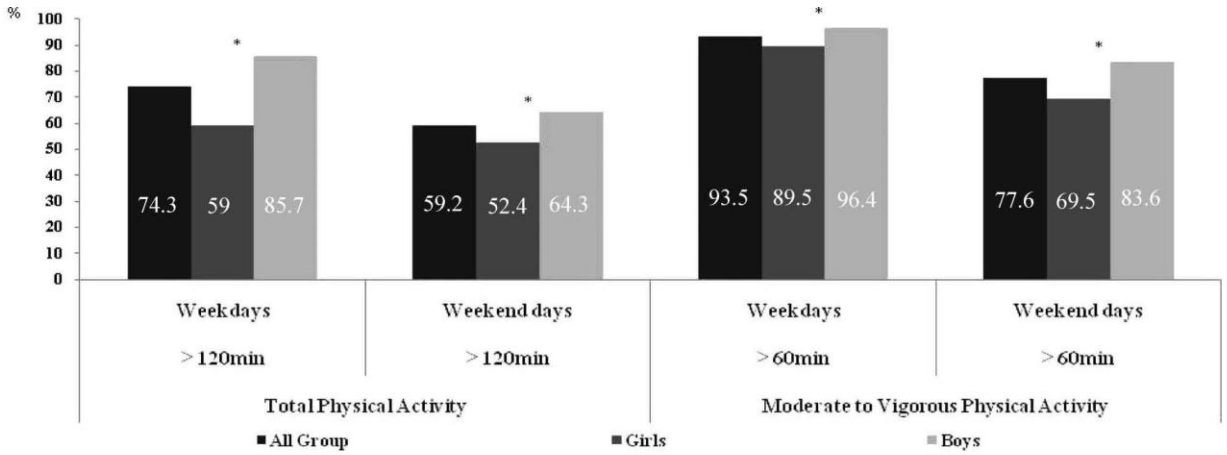

Figure 1. Total physical activity and moderate-to-vigorous physical activity recommendations for weekdays and weekend days in boys and girls ($P < 0.05$).

Discussion

In the present study, we assessed participation by preschool children in total physical activity and moderate-to-vigorous physical activity on weekdays and weekend days. We also assessed compliance with recommendations for total physical activity (National Association for Sport and Physical Education guidelines) and moderate-to-vigorous physical activity on weekdays and weekend days in the same children. Although attention has been focused on health-related physical activity as a key factor in public health promotion, to the best of our knowledge little attention has been paid to health-related physical activity recommendations in kindergarten children, using objective measures, and few studies have considered objective measurement of sedentary behavior and physical activity simultaneously in the same sample.

The results of the present study suggest that boys were engaged in more ($P < 0.05$) total and moderate-to-vigorous physical activity than girls, which is consistent with most studies of preschool children (Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008). Our results also show that, irrespective of gender, children were significantly more active (total and moderate-to-vigorous physical activity) on weekdays than weekend days. It is difficult to make comparisons across studies for weekdays and weekend days because of differences in age of samples and measurements tools. However, two studies in older children using heart rate monitoring reported slightly higher mean values on weekdays than on weekend days for moderate-to-vigorous physical activity in young girls (Treuth, Butte, Puyau, & Adolph, 2000; Treuth et al., 2007).

In both sexes, sedentary behaviour accounted for most time on weekdays (83%) and weekend days (83.9%), while moderate-to-vigorous physical activity accounted for 12.1% of time on weekdays and 11.5% on weekend days. Several studies have shown that preschool children spend most time each day time engaged in sedentary/light activities (Fisher et al., 2005; Kelly, Reilly, Grant, & Paton, 2005). For example, Kelly et al. (2005) and Fisher et al (2005) reported lower rates of sedentary activities in preschool children (78% and 76.3%, respectively), while others reported a slightly higher percentage of time spent in moderate-to-vigorous physical activity (13%) (Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004). To the best of our knowledge, however, none of these studies assessed compliance with current physical activity recommendations. Thus, our findings are novel. These guidelines state that preschool children should accumulate at least 120 min of physical activity per day (60 min daily of structured and at least 60 min daily of unstructured of physical activity) (National Association for Sport and Physical Activity, 2002) and participate in at least 60 min of moderate-to-vigorous physical activity per day (Strong et al., 2005). Our results show that around 75% and >90% of the children met the NASPE recommendation for total physical activity as well as the moderate-to-vigorous physical activity recommendations on weekdays respectively. Although our results show clearly that, in relative terms, sedentary and light activities accounted for most preschool children's time on weekdays and weekend days, the physical activity recommendations preclude the label of "sedentariness", despite the high amount of time spent in sedentary behaviours each day. Other studies using these physical activity recommendations reported similar results. For instance, based on the NASPE recommendation, Okely and colleagues (Okely, Trost, Steele, Cliff, & Mickle, 2009) reported fewer children than us meeting it for

weekdays (56%) but a similar proportion for weekend days. Okely et al. also reported that all children met the moderate-to-vigorous physical activity recommendations. In a study of 5- to 6-year-olds, Telford and colleagues (Telford, Salmon, Timperio, & Crawford, 2005) reported 99% compliance with moderate and vigorous physical activity criteria. Another study with a smaller sample ($n = 39$), in which heart rate was used instead of accelerometers to assess physical activity, found that 71% and 46% of the participants met the NASPE recommendations on weekdays and on weekend days respectively (Benham-Deal, 2005). However, a recent study using accelerometers with 76 children showed that only 26% met NASPE recommendations and only 7% met moderate and vigorous physical activity recommendations (Cardon & De Bourdeaudhuij, 2008). Comparisons of physical activity in preschool children based on published recommendations are difficult. Reasons for this include methodological issues, such as the cut-points used and epoch length chosen, which can modify the final outcome. For instance, a study that used >3200 counts per minute to define moderate and vigorous physical activity found that only 4% of time each day was spent in such activity (Reilly et al., 2003), whereas using the value applied in the present study (>1680 counts per minute) would give a figure of 12%. Furthermore, in older children it has been shown that epoch length might affect the amount of moderate and vigorous physical activity found (Nilsson, Ekelund, Yngve, & Sjostrom, 2002).

Sedentary behaviour is an individual variable that affects health (Pate & O'Neill, 2008), but it is unclear whether such behaviour replaces physical activity in young children or not. In the present study, despite the children engaging in sedentary behaviour for 83% of their time on weekdays, most (70%) also met the daily physical activity recommendations and 90% achieved the moderate-to-vigorous physical activity recommendations on weekdays. Furthermore, compliance with total and moderate-to-vigorous physical activity recommendations on both weekdays and weekend days was 51.8%. Thus, although the children in the present study spent most of their time each day in sedentary behavior, they were active enough to meet physical activity recommendations. Our results suggest that attention should be paid to both these constructs – physical activity and sedentary behaviour – independently for a correct interpretation of activity at this age because they might not necessarily counteract each other.

The strengths of this study include: our focus on patterns of physical activity in preschool children; a comparison of both total and moderate-to-vigorous physical activity on weekdays and weekend days; an assessment of compliance with physical activity recommendations using an objective physical activity measure; and the independent assessment of both physical activity and sedentary behaviour. The 5-s epoch used in this study appears to capture a greater amount of data in preschool children (Vale et al., 2009).

Some limitations of the study should also be recognized. The study included preschool children from one metropolitan area only, which make difficult to generalize the findings. Furthermore, it is not possible to infer causal relationships using such a cross-sectional design.

In conclusion, the results of this study suggest that despite 83% of preschool children's time each day being spent in sedentary behaviour, most children meet daily physical activity and moderate-to-vigorous physical activity recommendations on weekdays. Attention needs to be paid to these two constructs – physical activity and sedentary behaviour – independently for a correct interpretation of activity at this age because they might not necessarily counteract each other.

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Paper IV

Vale S.; Santos, R.; Soares-Miranda, L.; Silva P.; Mota J. **The importance of Physical Education Classes in Preschool Children.** *Journal of Paediatrics and Child Health***.** *In Press.*

Journal of Paediatrics and Child Health

Original Article

The importance of Physical Education Classes in Preschool Children

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Abstract

Aim: The purpose of this study was (a) to analyze differences between Total Physical Activity (TPA) and Moderate-to-Vigorous PA (MVPA) of preschool children during daily school hours when they attended the physical education class (PED) and days school days without PE class (NPED) and (b) to assess the contribution of PE classes to TPA in school hours. **Methods:** The sample comprised 193 preschool healthy children (96 girls) aged from 3 to 5 years old and was conducted between February and December of 2008. Children wore accelerometers for at least 4 consecutive days during school hours. Data was analysed with specific software, age-specific counts-per-minute cut-offs points and a 5 seconds epoch were used. Independent and General Linear Model repeated measures were used to assess differences between gender and differences between different days within each gender, respectively. **Results**: Boys engaged more MVPA than girls ($p<0.05$). During PED preschool children engaged significantly more in TPA and MVPA than during NPED ($p<0.05$). PE class contributed, on average, 27.7% for the TPA and 32.8% of daily MVPA during PED in both gender. **Conclusion**: The results of this study suggest that structured physical activity such as a PE class increased the daily TPA and MVPA level of pre-school children.

Key Words: Acelerometry; Preschoolers; Physical Activity; Physical Education Class

Introduction

Children's physical inactivity has been categorized as a modifiable risk factor for lifestyle related diseases and many of the known risk factors for chronic diseases are also presented in youth (1-3). Furthermore, it has been suggested that physical inactivity during youth is linked to several health-related risks in adulthood (4). Some studies indicate that levels of total energy expenditure and physical activity (PA) levels in preschool children are very low (5-9) and levels of sedentary behaviour (SB) exceptionally high (6, 7, 10, 11). The benefits of reducing a sedentary lifestyle and promoting PA have become increasingly important for public health (12, 13). Hence, the measurement of the PA at early ages is a key factor in lifestyle evaluation and a tool for its control. On other hand, targeting children's patterns of PA is especially important given that increasing PA in childhood might be essential for the lifetime of regular PA (4, 14). Additionally, there is a need to understand the factors that influence PA in preschoolers and to learn how to help them to be more active.

Current health-related PA guidelines suggested that preschool children should accumulate at least 120 minutes of PA per day (60 minutes daily of structured and 60 minutes daily of unstructured of PA) (15) for a healthy lifestyle. Some studies in children and adolescents have described daily patterns of PA, describing differences between defined time blocks within days (16, 17). Although, in some countries, most PA for children occur outside of the school environment (18), schools have long been recognized as key settings to promote and to contribute to PA guidelines because children spend a large amount of their day in school (19). School Physical Education (PE) is recognized as the most widely available tool for promoting PA among children and adolescents (20). However, limited attention has been given to preschool children PE activities at school, as well as, to the contribution that kindergarten school PE to the overall daily Total Physical

Activity (TPA) and Moderate-to- Vigorous Physical Activity (MVPA) participation. Indeed, previous studies of PA in young children have been limited by the lack of adequate measures of PA. It is well known that at this age, children are unable to self-report their PA accurately (21, 22), and surrogate reports by parents and other adults have limited validity (23). Recent reviews have concluded that accelerometer provides an objective, practical, accurate and reliable means of quantifying the amount and intensity of habitual PA in preschool children (24, 25). Thus, little is known about the activity patterns of pre-school children and no information is available whether there are substantial differences in days where children are involved in PE classes at school compared to those where they are not. This might be an important topic since further strategies of PA promotion targeting early childhood should be developed based on substantial preschools population data.

Therefore, the purposes of this cross-sectional study were (a) to analyze differences in TPA and MVPA of preschool children during daily school hours when they attended the physical education class (PED) compared school days without PE class (NPED) and (b) to assess the contribution of PE classes to the TPA in school hours.

Materials and Methods

Participants and setting

The participants of this study derived from the Preschool Physical Activity, Body Composition and Lifestyle Study (PRESTYLE) carried out in 2008. A random sample of 495 children, aged 2 to 5 years old, was recruited from 6 kindergartens in the District of the Metropolitan area of Porto, in Portugal. While, only 202 children wore accelerometer for 5 consecutive days during school time. In this study we included only children aged 3 to 5 years old, who had at least 4 complete school days of accelerometer data, and that attended to at least one PE class, weight and height. The final sample included 193 healthy

preschool children (96 girls) aged 3 - 5 years old ($\overline{X}$ = 4.8 ± 0.8 yrs-old). Mean body height was 107.5 ± 6.6 cm and mean body mass was 19.8 ± 3.6 kg. These values were within the normal ranges for children of this age (6, 10, 26). Informed written consent was obtained from the children's parents or guardian and the school principal. Study procedures were approved by the Portuguese Foundation for Science and Technology and by the Ethics committee of Physical Activity and Health PhD program of our Faculty.

Anthropometric measures

Body height and body weight were determined by standard anthropometric methods. Height was measured to the nearest mm in bare or stocking feet with the adolescents standing upright against a Holtain portable stadiometer. Weight was measured to the nearest 0.10 Kg, lightly dressed (underwear and t-shirt) using a portable digital beam scale (Tanita Inner Scan BC 532).

Physical Activity

Daily PA was measured using Actigraph accelerometer, model GTM1 (Pensacola, FL 32502. USA). This is a small, lightweight, uniaxial device. This accelerometer produces 'raw' output in activity counts per minute (cpm), which gives information about the total amount of PA (27). Alternatively, accelerometer output can be interpreted using age specific cut-points, which describe different intensities of PA. Data reduction, cleaning, and analyses of accelerometer data were performed using a specially written program (MAHUffe; available in www.mrc-epid.cam.ac.uk), described and used previously (28, 29). Data was analysed using specific paediatric cut-points, which have been validated for young children (30). The age-specific cpm cut-offs for 3, 4 and 5 years old children with regard to different activity intensities (cpm) were respectively: Sedentary

- ≤1204. ≤1452. ≤1592; Light PA - >1205. >1453. >1593; MVPA - ≥2457. ≥3245. ≥3561. These cut-points were used and recommended by Sirard (30) and Alhassan (10).

For the purpose of this study the epoch duration or sampling period was set to 5 seconds (5-s) in order to detect more accurately the spontaneous and intermittent activities of the children (31, 32).

Protocol

The study was conducted on five consecutive schooldays (Monday to Friday) between February and December of 2008 to account seasonal variation, during school hours, for a minimum of 6 hours per day. Teachers were instructed to place the accelerometer on the respective child on the arrival at school and remove it before they went home. The accelerometer was firmly adjusted at the child's right hip by an elastic waist belt under clothing (own clothes and school coat). A data sheet was given to the children's teachers, who were instructed to record the time when the monitor was attached in the morning and detached in the evening. They were also instructed to note every time children performed any activity like swimming, gymnastics, walking, gardening and simply going to the recess. Activities were not prescribed or directed by the teachers and researchers. Children participated in normal activities with their classmates.

Physical Education Class

PE class formed part of the regular school curriculum and was carried out once a week by a specialized PE teacher. Each session lasted 50 to 60 minutes and the sessions provided different kind of activities such as ball games, calisthenics, gymnastics and exercises to improve coordination, flexibility and fundamental motor skills (jumping,

throwing, etc.…). These activities were not reported by the authors, but each teacher was asked about the class content, which was not modified due to the realization of the study.

Statistical analysis

All data was checked for normality prior to statistical analysis. Descriptive statistics were used in order to characterize and describe the sample. The daily school time spent in MVPA was calculated by summing the minutes of moderate and vigorous PA for each day. To examine the patterns of PA participation, data from the school time was divided into two groups: (1) PE class day (PED); and (2) school days without PE class (NPED). Gender differences in TPA and MVPA between PED and NPED were tested with Independent sample T-Test and General Linear Model (GLM) – repeated measures were used to analyze differences in TPA and MVPA between PED and NPED within each gender and interaction between genders. All statistical analysis was performed using SPSS 15.0 for windows. The level of significance was set at $p<0.05$.

Results

Table 1 summarizes PA patterns of the entire sample and of each gender. On average, boys were more active than girls ($p<0.05$).

Insert Table 1

Class duration ranged between 50 and 60 min. Mean values for TPA and MVPA for the PED and NPED are shown in Figure 1.

Insert Figure 1

Using GLM –repeated measures, NPED had significantly lower mean TPA and lower mean MVPA than PED, in both genders ($p<0.05$). During PED preschool children engaged significantly more in TPA and MVPA (66.40 min.; 26.55 min.) than during NPE (55.45 min.; 20.16 min.) ($p<0.05$). This represents an increased TPA and MVPA participation of 23.5% and 39% in girls and 24.2% and 43% in boys, respectively, during the PED.

There wasn't a significant interaction between the genders for TPA ($F=0.410$; $p=0.523$) and MVPA ($F=0.768$; $p=0.382$), therefore PE class was analyzed taking into consideration the whole sample. Thus, PE class contributed on average 27.7% for the TPA and 32.8% for daily MVPA during PED in both gender (Figure 2).

Insert Figure 2

Discussion

This study reports information about the participation of preschool children in MVPA during school hours' period, comparing PED and NPED.

The data of the present study suggested that, in both genders, PED was effective in increasing TPA and MVPA levels. Indeed, during PED pre-school children engaged significantly more in TPA and MVPA (66.40 min.; 26.55 min.) than during NPE (55.45 min.; 20.16 min.) ($p<0.05$). This represents an increased TPA and MVPA participation of 23.5% and 39% in girls and 24.2% and 43% in boys, respectively, during the PED. To the best of our knowledge no data has focused its attention on the kindergarten PE class contribution to health-related daily PA recommendations, therefore comparison of results are difficult. However, such data is valuable for the designing of interventions to increase

PA, as well as, for tailoring individual exercise prescription as described in other specific groups (33). Furthermore, in the context of increasing levels of PA since early childhood these findings are worthy to comment. Indeed, general guidelines suggested that preschool aged children should accumulate at least 120 minutes of PA per day (60 minutes daily of structured and 60 minutes daily of unstructured of PA) (15). This might be particularly important because physical inactivity is an important contributing factor to the maintenance of childhood obesity (34, 35) and recent data showed high rates of obesity even in such **a** young age group (26, 36, 37).

Quality PE can make important contributions to public health (20). According to our data, PE represented a good opportunity for children to accumulate PA.

Our data highlights that PE class contributed on average 27.7% for the TPA in the PED. Moreover, during the PED, MVPA increased on average 32.8% compared with NPE. Which is important even though the PA recommendations do not make reference to intensity of physical activity for these ages. Whereas some children take this opportunity others do not and significant individual differences in PA levels were evident. In fact, our study showed large standard deviations records suggesting wide individual variations in PA. This high variability in TPA and MVPA levels occurred during the day, because children may have too many opportunities where they could freely choose to be sedentary or **to** participate in physical activities of various intensities (38).

Based on our outcome we can suggest that structured of PA, such as PE classes are important contributors of daily TPA and MVPA. Thus, PE at this young age might be an interesting and valuable strategy not only to increase TPA but also to stimulate motor development. Once, children with better developed motor skills may find it easier to be active and engaged in more PA (39).

The strengths of this study are the focus on patterns of PA in preschoolers, and the fact that it addresses differences between PED and NPED using an objective PA measure, which has not been carried out so far and using age-specific PA cut-points thresholds (25, 30, 40). Some limitations of the study should be recognized. The study included preschool children from one metropolitan area only, which makes it difficult to generalize these findings. Further, it is not possible to inferred causal relationships with cross-sectional design. Nevertheless, this study focuses on the assessment of TPA and MVPA levels in a preschool sample using an objective measure with a high compliance rate during school hours. This enhances the confidence in our findings because it was suggested that objective measures such as accelerometers provide more valid PA assessment in children (25). The 5 seconds epoch used in this study, it is preferable as it captures larger amount of data has already been shown in other study (31, 32) and it is more accurate to assess MVPA (41). Additionally, the large standard deviations suggest wide individual variations addressing the importance of the participants' intra-individual variability in PA behavior. However, other studies should be carried out to replicate our data. The acknowledgement that children spend a large amount of their day in school and day of PE class was effective in increasing TPA and MVPA levels, so future longitudinal studies should examine its association with some health indicators, such as obesity.

Conclusion

In conclusion, the results of this study suggest that structured PA such as a PE classes may increase the daily TPA and MVPA levels in pre-school children, emphasizing the importance of PE classes at these ages.

Acknowledgements

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		All (n=193)	Boys (n=97)	Girls (n=96)	*p*
TPA	PED (minutes)	66.40±22.08	70.49±24.28	62.28±19.38	*p=0.009*
	NPED (minutes)	55.45±17.17	59.14±17.25	52.14±16.06	*p=0.006*
MVPA	PED (minutes)	26.55±12.18	29.39±13.14	24.08±11.11	*p=0.005*
	NPED (minutes)	20.16±9.12	22.03±9.14	18.27±8.28	*p=0.003*

TPA – Total Physical Activity; MVPA = moderate-vigorous physical activity. All data expressed as mean±SD

Table 1 - PA patterns among gender between physical education class day (PED) and between average of the school days without PE class (NPED)

Figure 1 - Mean values for Total Physical Activity (TPA) and for Moderate-to-Vigorous Physical Activity (MVPA) for the physical education class day (PED) and days without PE class (NPED) for boys and girls

Figure 2 – Physical Education Class contributed for the Total Physical Activity (TPA) and for Moderate-to-Vigorous Physical Activity (MVPA) in the physical education class day (PED) on average in both gender.

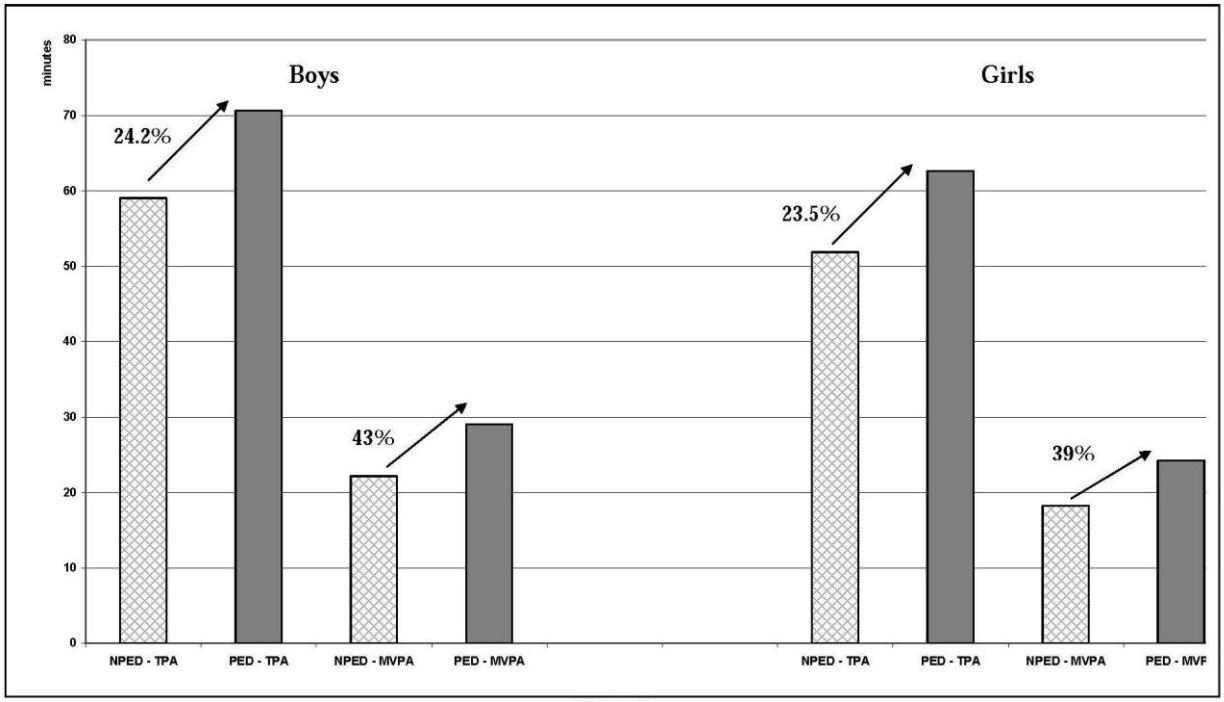

Figura 1

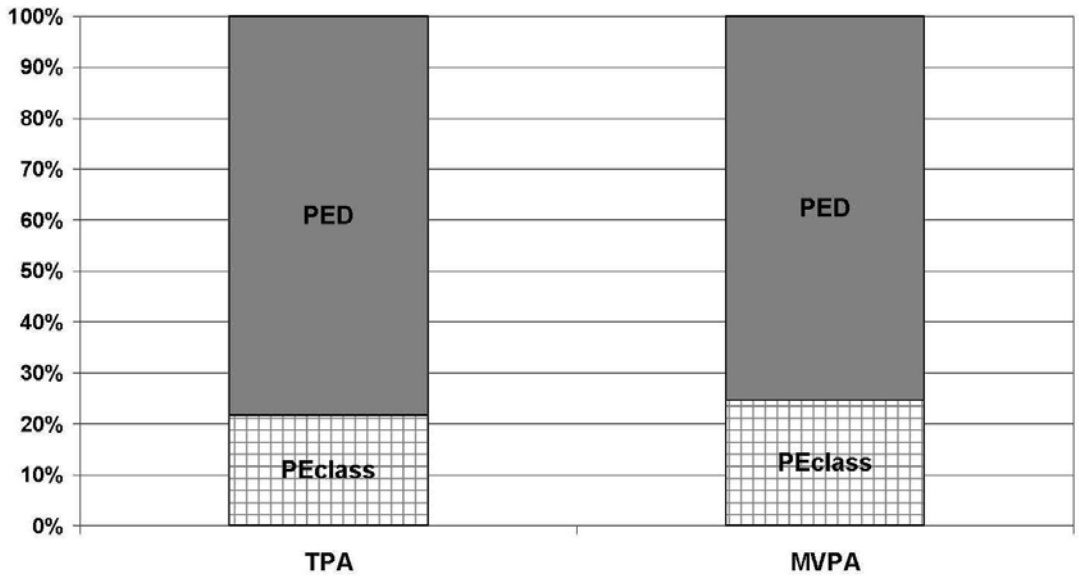

Figura 2

Paper V

Vale S.; Santos, R.; Soares-Miranda, L.; Moreira, C.; Ruiz, J.J.; Mota J. **Objectively measured physical activity and body mass index in pre-school children** *(review after revision)*

Objectively measured physical activity and body mass index in pre-schoolers

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ABSTRAT

Aim: To examine the association between objectively measured physical activity (PA) and body mass index (BMI) in pre-school children.

Methods: The study comprised 281 children (55.9% boys) aged 4-6 years. PA was measured by accelerometer. Children were categorized as non-overweight (NOW) and overweight/obese (OW) according to the sex-adjusted BMI z-score (<1 and ≥1, respectively).

Results: Total and moderate intensity PA were not associated with BMI. We observed that a higher proportion of OW children were classified as low vigorous-PA compared to their NOW peers (43.9 vs. 32.1%, respectively $p>0.05$). Logistic regression analysis showed that children with low vigorous-PA had higher odds ratio (OR) to be classified as OW compared to those with high vigorous-PA (OR= 4.4; 95%CI: 1.4-13.4; p= 0.008) after adjusting for BMI at first and second years of life and other potential confounders.

Conclusion: The data suggests that vigorous-PA may play a key role in the obesity development already at pre-school age.

INTRODUTION

The prevalence of childhood obesity has been rising during the past decades in many parts of the world [1]. In Portugal, there is a high prevalence of overweight and obese children [2] and adolescents [3]. This picture is particularly alarming owing to the increasing risk of developing cardiovascular diseases in overweight and obese individuals [4, 5]. Over the long term, childhood/adolescence overweight is strongly associated with adult obesity [6, 7]. Therefore, it is of clinical and public health importance to examine the risk trends in order to develop effective preventive strategies targeting those at risk start as early as possible.

Human obesity is a multi-factorial disorder where both genes [8] and lifestyle factors, including diet and physical activity [9] are important contributors. Both maternal and paternal body mass index (BMI) has also a strong influence on offspring's risk of obesity [10, 11]. Other determinants of childhood obesity include birth weight and weight gain that occur during the first years of life [12-14].

It has been suggested that obesity during the pre-school years is associated with other clinical factors easily assessed at birth [15]. For instance, it was found an association between birth weight and the risk of being obese in children at the age of 4, 8, 10 and 12 years [16].

Besides the previously mentioned factors, there exist other potentially modifiable factors that increase the risk of overweight in childhood and adolescence. These include: (i) intrauterine life: excessive gestational weight gain [17, 18], maternal smoking during pregnancy [13, 19, 20]; and infancy and

pre-school period: reduced breastfeeding duration [21], excessive weight gain in the first 2 years of life [12, 22], excessive television [23-25], short sleep duration [12, 26, 27], and low levels of physical activity (PA) [28-30].

Studies examining the associations between PA and body fat in young children are scarce [12, 28, 30], and to the best of our knowledge, few studies have estimated the associations between objectively measured PA and BMI in preschoolers [28, 30]. Furthermore, there is no information available in Portuguese population.

The purpose of this study was to analyze the association between objectively measured PA and BMI in Portuguese pre-schoolers.

METHODS

Participants and data collection

This is a cross-sectional study carried out in Portuguese (metropolitan area of Porto) kindergartens enrolled in the Preschool Physical Activity, Body Composition and Lifestyle Study (PRESTYLE). A total of 281 healthy pre-school children (55.9% boys) aged 4-6 years with complete information on the variables of interest were included in the study. Data collection took place between April 2009 and November 2009.

Informed written consent was obtained from parents and school supervisors. Study procedures were approved by the Portuguese Foundation for Science and Technology and by the Scientific Board of Physical Activity and Health PhD program.

Anthropometric Measures

Body weight and height were measured by standard anthropometric methods. Body weight was measured to the nearest 0.10 kg, with participants lightly dressed (underwear and tee-shirt) using a portable digital beam scale (Tanita Inner Scan BC 532). Body height was measured to the nearest millimetre in bare or stocking feet with children standing upright against a Holtain portable stadiometer (Tanita). The measurements were repeated twice and the average was recorded. BMI was calculated as body mass (kg) divided by height (m) squared. Children were classified as either non-overweight (NOW) or overweight (OW) according to the sex-adjusted BMI z-score (<1 SD and ≥1 SD, respectively). Children were evaluated during school day by trained teachers.

Physical Activity

PA was measured using Actigraph accelerometers, model GTM1 (Pensacola, FL 32502. USA). This is a small, lightweight, uniaxial device. This accelerometer produces 'raw' output in activity counts per minute (cpm), which gives information about the total amount of PA [31]. The accelerometer output can also be interpreted using specific cut-points, which describes different PA intensities PA. Data reduction, cleaning, and analyses of accelerometer data were performed as described elsewhere [32, 33]. Data were analysed using specific paediatric cut-points, which have been validated for young children: ≥1100 and ≤1680 cpm for low PA [34], >1680 cpm for moderate PA, and >3360 cpm for vigorous PA (VPA) [35]. In this study, the epoch duration was set to 5

seconds, which seems to be more accurate and suitable concerning to the spontaneous and intermittent activities of the young children [36].

A minimum of 10 hours per day was considered as valid data for the analysis. Parents were instructed to place the accelerometer on the child right after waking up and remove it before going to sleep. The accelerometer was adjusted at the child's right hip by an elastic waist belt under clothing (own cloth and school coat). A data sheet was given to the children's teachers, who were instructed to record the time when the child arrived and leave the school. Activities were not prescribed or directed by the teachers or researchers. All children participated in normal activities with their classmates.

All PA intensity levels were defined by sex- and age specific tertiles. Children belonging to the first, second and third tertile were defined as low, middle and high PA level, respectively.

Potential Confounders

Pre and post natal and lifestyle factors

Mothers reported information regarding: gestational weight gain, maternal smoking during pregnancy, birth weight, as well as body weight and height during their offspring's first and second year of life. Gestational weight gain was categorized according to Institute of Medicine [37] as: below, optimal and above gestational weight gain, while maternal smoking during pregnancy was categorized as YES or NO.

Mothers also reported the amount of screen time (watching television and/or playing videogames) the child spends daily as well as the sleeping time

for both week days and weekends. Screen time questions were analyzed as continuous variables (converted to minutes) and also evaluated as a dichotomous variable based on young children recommendation [38]. Then, children were classified as accomplished guidelines (watching < 2h/day) and those who did not (watching ≥ 2h/day).

Mother Information

Mothers reported their body weight and height, and we calculated BMI. Mothers were categorized as normal weight (18.5 kg/m^2 ≥ BMI <25 kg/m^2); overweight (25 kg/m^2 ≥ BMI < 30 kg/m^2) and obese (BMI ≥30 kg/m^2) [39].

Socioeconomic status (SES) was defined as the mother's educational level and occupation [40]. The SES was defined based upon Portuguese Educational system a 9 years' education or less- sub secondary level (scored as 1), 10-12 years' education-secondary level (scored as 2) and higher education (scored as 3). Levels 1, 2 and 3 were considered as low, middle and high SES [41].

Statistical analysis

Means and standard deviations were calculated to describe children's characteristics by weight status (i.e. NOW and OW).

Comparisons between weight status and PA patterns were conducted with t –test for continuous variables and chi-square test for categorical variables.

Following bivariates correlation analysis we conducted logistic regression to examine the association between weight status and all other variables (physical activity patterns, gestational weight gain, smoking during pregnancy, BMI first year of life, BMI second year of life, daily screen time, daily sleep time)

A stepwise logistic regression analysis was performed to examine the association between PA and weight status, adjusted for all variables independently associated with weight status.

Statistical analysis was performed using the SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). The level of significance was set at p □ 0.05.

RESULTS

Table 1 shows descriptive statistics of pre-schoolers and parents by overweight status. The prevalence of overweight was 14.6%. Overweight (OW) children were heavier, taller and had higher BMI than their NOW counterparts ($p \leq 0.05$). We observed no statistical significant differences between weight status categories in minutes of total, MPA and VPA. However, the data showed that a proportion of OW children (43.9%) were classified low VPA compared to NOW children (32.1%) ($p > 0.05$).

Table 1 – Descriptive Statistics of study participants

	All Group N=281	**N-OW N=240**	**OW N=41**	***p***
Age (years)	5.03±0.81	5.01±0.82	5.14±0.72	*0.264*
Weight (Kg)	21.11±4.42	20.12±3.14	27.92±5.73	***<0.001***
Height (m)	1.11±0.08	1.10±0.08	1.14±0.08	***0.005***
BMI (KG/m2)	17.03±2.12	16.43±1.29	21.11±2.20	***<0.001***
BMI Zscore		-0.28±0.61	1.92±1.04	***<0.001***
TPA (minutes)	134±35	134±36	133±29	*0.863*
MPA (minutes)	58±14	58±14	58±13	*0.882*
VPA (minutes)	38±14	38±14	35±12	*0.293*
Physical Activity Patterns (%)				
TPA				
Low Activity	32.4	33.3	26.8	
Middle Activity	34.9	32.9	46.3	*0.249*
High Activity	32.7	33.8	26.8	
MPA				
Low MPA	32.4	33.3	26.8	
Middle MPA	35.2	33.3	46.3	*0.273*
High MPA	32.4	33.3	26.8	
VPA				
Low VIG	33.8	32.1	43.9	
Middle VIG	33.5	32.5	39.0	*0.064*
High VIG	32.7	35.4	17.1	

TPA – Total Physical Activity; MPA – Moderate Physical Activity; VPA – Vigorous Physical Activity

Logistic regression analysis showed that children with low vigorous-PA had higher odds ratio (OR) to be classified as OW compared to those with high vigorous-PA (OR= 4.4; 95%CI: 1.4-13.4; p= 0.008) after adjusting for BMI at first and second years of life and other potential confounders (Table 2).

Table 2 – Univariable and Multivariable Logistic Regressions

	Univariable Effects (odds ratio (95% CI))	**P value**	**Multivariable Stepwise effects* (odds ratio (95% CI))**	**P value**
TPA (Low TERTILE)	1.7 (0.8-3.9)	*>0.05*		
TPA (Middle TERTILE)	1.0 (0.4-2.5)	*>0.05*		
TPA (High TERTIL) - REF				
MPA (Low TERTILE)	1.7 (0.8-3.9)	*>0.05*		
MPA (Middle TERTILE)	1.0 (0.4-2.4)	*>0.05*		
MPA (High TERTIL) - REF				
VPA (Low TERTILE)	**2.8 (1.1-7.2)**	***0.027***	**4.4(1.4-13.4)**	***0.008***
VPA (Middle TERTILE)	2.5 (0.9-6.4)	*>0.05*	2.9 (0.9-8.8)	*>0.05*
VPA (High TERTILE) - REF				

TPA – Total Physical Activity; MPA – Moderate Physical Activity; VPA – Vigorous Physical Activity
* Adjusted for Birthweight. BMI 1 year. BMI 2 years. Gestacional Weight Gain. Maternal Smoking during pregnancy. Scream and Sleep Time and Mother BMI and Education.

DISCUSSION

This study examined the association of different PA intensity levels with weight status of Portuguese pre-schoolers after adjusting for several potential confounding factors. This is an important and relevant topic since, to the best of our knowledge, little is known about how PA intensity is associated with obesity in pre-school children. Our data showed that differences in levels of VPA were associated with weight status in children as young as 4-6years. This is worthy to notice because our data suggest that the VPA influenced the change in BMI from those earlier ages. Despite that, no statistical significant differences were found for levels of total and moderate PA.

Our findings concur with other studies showing that low levels of VPA were associated with body fatness during the adiposity rebound period [30]. Further, they also agree with studies in children and adolescents showing that only VPA (but not lower intensity levels) was associated with body fat [42]. Additionally, it was shown that within intervention groups, those who participated regularly and maintained the highest heart rates during PA sessions showed the greatest decreases in body fat and the greatest increases in bone density [43, 44]. On the other hand, adolescents who engaged in relatively large amounts of free-living vigorous PA were likely to be relatively fit and lean. [45]. These findings are worth commenting in terms of both PA interventions and public health policies.

The large standard deviations found in our study suggest a wide individual variations and highlight the importance of the participants' intra-individual variability in PA behaviour. Therefore, variation in PA levels may be

particularly important in preschool children with regard to weight status. While there is a need to better understand the factors that influence PA in pre-schoolers and to learn how to help them to become more active, our study shows that PA promotion and interventions should focus on the more intense PA activities. Children have a natural tendency towards movement, there is information suggesting a decline of discretionary time on children's daily life [29] and, thus, the time allocated to spontaneous PA, witch, in turn, tend to be highly active [46] it is reduced and several sedentary behaviors such as TV viewing, video games and other activities involving many hours standing took the lead on children's daily behaviour [12, 24]. Therefore, promotion of organized PA programmes such as physical education at schools and organized sports activities [29] that usually request more intense activities must be taken into account when PA promotion strategies are being developed.

Some limitations of this study should be recognized. First, the study included pre-school children from one metropolitan area, which made it difficult to generalize these findings. Secondly it is not possible to inferred causal relationships between pre-school PA level and overweight status with such a cross-sectional study design. Nevertheless, this study focuses on the assessment of PA levels in a pre-school sample using an objective measure, which enhances the confidence of our findings owing to the fact that accelerometers provide more valid PA assessment in children [35].

CONCLUSION

Our data suggests that VPA may play a key role in the obesity development already at pre-school age.

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5. Main Findings, Study Limitations and Conclusions

5. Main Findings, Study Limitations and Conclusions

The PRESTYLE provides, for the first time, a general idea of the physical activity (PA), body composition and lifestyle factors in a sample of Portuguese preschoolers. This study also highlights the prevalence of overweight and obesity; analyzes PA patterns and relationships between PA and obesity among preschoolers.

Overweight and Obesity

The prevalence estimates of overweight/obesity found in this Portuguese sample was 33.1% (37.2% in girls and 29.6% in boys, $p<0.05$). Our data showed similar values to those suggested in other studies among preschool children, also characterized by high levels of overweight and obesity (Kremer et al., 2006, Maffeis et al., 2006, Moschonis et al., 2008) and clearly highlighted the concerns with regard to obesity level in the pediatric population in Portugal. Furthermore, there was a suggestion that trends in overweight and obesity with age might differ between boys and girls in our sample: girls seem to be at higher risk than boys. Other reports confirm these findings (Hinkley et al., 2008).

The preschool period, around the time of the adiposity or body mass index rebound (Daniels, 2006), was considered as possible critical period for obesity development during which the long term regulation of energy balance may be programmed (Dietz, 1997). Moreover, studies suggest that adequate participation in regular PA during childhood might be of critical implication in the

primary prevention of chronic disease in adulthood (Raitakari et al., 1994, WHO, 2004). The reasons of this important health problem are not clear, once some studies revealed that not only genetic but also environmental and behaviour factors are involved in the development of obesity at theses ages (Parsons et al., 1999, Burdette and Whitaker, 2005, Moschonis et al., 2008). Consequently, future interventions might target early life, and focus on environmental changes attempting to modify factors in early childhood, which are independently related to later risk of obesity.

Physical Activity

Some recent studies pointed-out that even preschoolers are characterized by low PA levels and high levels of sedentary behaviour (Jackson et al., 2003, Reilly et al., 2004, Kelly et al., 2005, Reilly et al., 2005). This increasing evidence is particularly worrying once PA in these ages appears to be important, not only due to healthy growth and development, but also due to the establishment of regular patterns of activity which tend to persist during adulthood.

One common characteristic across the preschoolers is the sporadic and intermittent nature of their PA, Indeed, young children's PA consists of short bursts of MVPA interrupted by periods of lower intensity activity (such as walking) or resting (Bailey et al., 1995). Consistent with these characteristics, it is important to choose the most appropriate method to assess PA in preschoolers. Objective assessment of physical activity using body worn

movement monitoring technology, such as accelerometers, can provide researchers and practitioners with immensely valuable information about the pattern of daily physical activity and its relationship with indicators of obesity in youth. In this context, in our study we found that children showed lower time spent in MPA (9.33 min), VPA (7.49 min) and MVPA (16.41 min) when 60-s epoch was considered compared with the 5-s epoch. Our data agrees with findings in older children (Nilsson et al., 2002, Reilly et al., 2008) showing that a shorter epoch time is more susceptible to detected higher levels of VPA than a higher epoch time (60-s) did. Our data also gave additional support to those findings because we also found that a shorter epoch time (5-s) showed statistically significantly higher time spent in MPA and MVPA. Given the fact that PA guidelines stressed the accomplishment of 60 min of MVPA daily (Strong et al., 2005), the difference between the two epoch lengths (~17 min.) corresponds about 28% of the total daily time allocated to guidelines achievement. A recent study showed similar results (Oliver et al., 2009) and found that epochs of 5 sec or less may have been more appropriate to capture PA intensity. Thus, our results suggest that the 5-s epoch might be better adapted to the preschooler's activity pattern.

Sedentary Behavior *vs* Physical Activity

In fact, sedentary behavior has become more common among younger generations. In both genders, sedentary behavior accounted for the majority of the weekday's time and weekend time (weekdays: 83% vs. weekend: 83.9%).

Main Findings, Study Limitations and Conclusions

Several studies have shown that pre-school children spent the majority of their daily time engaged in sedentary /light activities (Fisher et al., 2005, Kelly et al., 2005). On the other hand boys engaged significantly more ($p<0.05$) in total PA and MVPA than girls, which is consistent with the majority of studies among preschool children (Hinkley et al., 2008). On average, during weekdays preschool children engaged significantly more ($p<0.05$) in total PA and MVPA than during the weekend. Comparisons across the studies for weekdays and weekend days are somewhat difficult due to age of the subject's samples and differences from measurements tools. However, two studies in older children, using objective measures by heart rate monitoring reported slightly higher means on weekdays than on weekends at either MPA or VPA in young girls (Treuth et al., 2000, Treuth et al., 2007). Although, based on these recommendations altogether, 74.3% and 93.5% of the children met the *National Association for Sport and Physical Education, 2002* guidelines and MVPA recommendations (Strong et al., 2005), respectively on weekdays, whereas the compliance with both recommendations decreased substantially in both genders during the weekend.

Physical Education Class

The day with physical education class was effective in increasing PA levels. On the day with physical education class children engaged significantly more in total PA and MVPA (66.40 min.; 26.55 min.) than during the average of the others days (55.45 min.; 20.16 min., $p<0.05$).

According to our data, physical education classes represented a good opportunity for children to accumulate PA because it contributed on average to 27.7% of the total PA per day on the day with physical education class. Moreover, during the day with physical education class, MVPA increased on average 32.8% compared with the average of the other days.

Physical Activity vs Overweight and Obesity

Differences in levels of VPA were a strong predictor of children OW. No significant statistical differences were found for levels of total and moderate activity.

Our data agrees with others by showing that low levels of VPA were associated with fatness during the adiposity rebound period (Janz et al., 2002). Further, it also agrees with data in adolescents showing that low levels of body fat were associated with a greater amount of VPA but not with MPA (Ara et al., 2009).

The large standard deviations found in our study suggested wide individual variations and highlighted the importance of the participants' intra-individual variability in PA behaviour. Therefore, variation in PA levels may be particularly important in preschool children with regard to obesity status. While there is a need to better understand the factors that influence PA in preschoolers and to learn how to help them to be more active, our study shows that PA promotion and interventions should focus on the most intense PA activities.

Main Findings, Study Limitations and Conclusions

Although usually children have a natural tendency towards movement, there is information suggesting a decline of discretionary time on children's daily life (Strong et al., 2005) and, thus, the time allocated to spontaneous PA, which, in turn, tends to be highly active (Vale et al., 2010). It is reduced and several sedentary behaviors such as TV viewing, video games and other activities involving many hours standing dominated children's daily behaviour (Dennison et al., 2002, Reilly et al., 2005). Therefore, promotion of organized PA programmes such as physical education classes at schools and organized sports activities (Strong et al., 2005) that usually require more intense activities must be taken into account when PA promotion strategies are being developed.

This study is not without limitations. First, in paper I the sample is small and it is believed that a larger group of participants is needed to clarify to what extent the differences are important for public health strategies. Second, the studies included a convenience sample of preschool children from one metropolitan area only, which makes it difficult to generalize our findings. Furthermore, it is not possible to inferred causal relationships with a cross-sectional design.

Despite the limitations of our study, the results suggest that the high prevalence of overweight and obesity found are alarming and call for appropriate interventions. Future studies with nationally representative samples

are needed to clarify prevalence of overweight and obesity in preschool children in Portugal.

Regarding PA assessment with accelerometry, the epoch choice seems to be an important issue when PA prevalence rates are addressed in such young ages. Our findings suggested that using a 5-s epoch is better than a 60-s epoch to characterize the preschooler's activity pattern.

Children in our sample spend most part of their daily time in sedentary behavior but, on the other hand, they also spend enough time in active behavior that allow them to accomplish PA recommendations. Thus our data also suggests that attention should be paid to these two constructs - PA and sedentary behavior - independently for a correct interpretation of the results found at this age because these two behaviors might not necessarily counteract each other.

Structured PA, such as physical education classes are important contributors of daily total PA and MVPA. Thus, physical education classes at this young age might be an interesting and valuable strategy to increase total PA.

Higher levels of VPA but not in moderate or total physical activity were a strong predictor of obesity in preschool children.

Future longitudinal studies are required to examine PA associations with some health indicators.

6. References

6. References

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