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Associations of Physical Activity and Maturity with Adolescents' Body Composition

Thesis submitted in order to obtain the Master´s Degree in the field of Human Kinetics, specialization in Exercise and Health

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To someone that is no longer among us, although always present in my heart as well as in everything I do.

Resumo

Introdução:

Durante a adolescência as diferenças na atividade física (AF) e composição corporal (CC) entre géneros é evidente, contudo as associações da maturidade nessas diferenças têm sido pouco estudados.

Objectivo:

Estudar as associações da AF e maturidade na CC de adolescentes.

Métodos:

Foram avaliados 180 adolescentes (97 rapazes e 83 raparigas com idade média de 13,8 anos). As medições antropométricas utilizadas foram obtidas de acordo com os procedimentos do International Society for the Advancement of Kinanthropometry (ISAK), à excepção do diâmetro abdominal-sagital (DAS). A massa gorda (MG) foi determinada a partir das equações de Slaughter et al. e a idade óssea através do método TW3 (raio-X). A AF foi avaliada através de questionário e acelerometria (Actigraph® GT1M). A análise estatística utilizada foi a regressão linear multifactorial (método *stepwise)*, com o *software* PASW 18.0.

Resultados:

Nos rapazes a maturidade explica 22% a 66% da variabilidade do índice de massa corporal (IMC), 13% da variabilidade do índice cintura-anca (ICA) e 16% a 59% da variabilidade do DAS. Os comportamentos activos e a AF muito vigorosa (AFMV) conjuntamente com a maturidade explicam 16% e 70% da variabilidade da DAS, respectivamente. 14% da variabilidade da massa gorda (MG) nos rapazes é explicada pela AF leve. Relativamente às raparigas nenhum dos fatores determinantes (AF ou maturidade) foram preditores da MG e ICA, contudo a variabilidade do IMC foi explicada pela AF moderada (AFM) (24%), comportamentos sedentários (28%) e por ambos (31%). A AFM também explicou 31% da variabilidade do DAS.

Conclusões:

Os resultados parecem indicar que existem diferenças de género para as determinantes da CC durante a adolescência. Os principais fatores preditores nos rapazes foram a maturidade, os comportamentos ativos e a AFMV e, nas raparigas, foram os comportamentos sedentários e a AFM.

Palavras-chave: adolescentes, actividade física, maturidade, composição corporal.

Abstract

Background:
During adolescence the differences in physical activity (PA) and body composition (BC) between genders become evident, nevertheless the associations of maturity in these differences have been scarcely studied.

Objectives:
To examine the associations of PA and maturity on adolescents' BC.

Methods:
The evaluation comprised 180 adolescents (97 boys and 83 girls, with an average age of 13,8 years). All anthropometric measures were obtained according to the International Society for the Advancement of Kinanthropometry (ISAK) procedures, with exception of the Sagittal Abdominal Diameter (SAD). Fat mass (FM) was determined by Slaughter et al. equations and skeletal age through the TW3 method (X-ray). PA was assessed through questionnaire and accelerometry (Actigraph® GT1M). Data analysis was performed using multifactorial linear regression analysis (stepwise method) with PASW 18.0 software.

Results:
In boys, the maturity explains 22% to 66% of the variability of body mass index (BMI), 13% of the variability of waist-to-hip ratio (WHR) and 16% to 59% of SAD's variability. The active behaviours and very vigorous PA (VVPA) along with maturity explains 16% and 70% of the variability of the SAD, respectively. 14% of the variability of fat mass (FM) in boys was explained by light PA. Regarding girls none of the determinant factors (PA or maturity) predict the FM and WHR, although the BMI's variability was explained by moderate PA (MPA) (24%), sedentary behaviours (28%) and both (31%). The MPA also explains 31% of SAD's variability.

Conclusions:
The results seem to indicate that there are gender differences for BC determinants during adolescence. The main predictive factors for BC in boys were maturity, active behaviours and VVPA and for girls these were sedentary behaviours and MPA.

Key words: adolescents, physical activity, maturity, body composition

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Abbreviations

Contributing to a less exhaustful reading, some abbreviations will be used instead of the most repeated words and as a replacement for most extensive nomenclature. Thus, abbreviations following are said abbreviations sorted by subject.

- **Physical activity abbreviations:**

  DEE – Daily Energy Expenditure

  LPA – Light Physical Activity

  MPA – Moderate Physical Activity

  MVPA – Moderate-to-Vigorous Physical Activity (MPA + TVPA)

  PA – Physical Activity

  QAPACE – Quantification de l'Activité Physique en Altitude Chez les Enfants

  TVPA – Total Vigorous (VPA + VVPA)

  VPA – Vigorous Physical Activity

  VVPA – Very Vigorous Physical Activity

- **Body composition abbreviations:**

  BMI – Body Mass Index

  BC - Body Composition

  FM – Fat Mass

  SAD – Sagittal Abdominal Diameter

  WHR - Waist-to-Hip Ratio

- **Maturity level abbreviations:**

  BA – Biologic Age

  CA – Chronological Age

  SA - Skeletal Age

  Relative SA – Relative Skeletal Age

Introduction

Obesity has revealed itself as an epidemic during the XXI century, its treatment imperative and early age prevention vital. This requires a multidisciplinary approach of professionals in health and education areas, considering the influence of family, environment and socio-cultural factors.

It is recognized that physical activity has a preponderant role in body composition modifications and obesity prevention. Furthermore, most children take part in adequate amounts of physical activity however these tend to decrease from adolescence to adulthood fore both genders. Thus, this stage is an important milestone for the intervention of the above mentioned professionals in order to reduce the prevalence and incidence of overweight, obesity and the associated comorbidities, such as cardiovascular diseases and musculoskeletal disorders.

In order to understand if the Portuguese children/adolescents reach the daily recommendations of physical activity, is essential to determine their baseline levels, consequently tracing an adequate intervention plan. However, the adolescence for itself comprises several changes in somatic, hormonal and sexual systems and to understand the associations of physical activity on the adolescents' body composition should been taking into account the maturity status.

This thesis has a cross-sectional design and was drawn to assess the associations of physical activity and maturity status on adolescents' body composition. To attain this purpose the literature review will approach issues of the mentioned areas. For the assessment of physical activity objective and subjective methods were used, accelerometry to attain time spent in physical activity and a questionnaire to attain the daily energy expenditure. To assess body composition anthropometric measurements were used, comprising body mass index, fat mass, waist-to-hip ratio and sagittal abdominal diameter. The maturity status was assessed by skeletal age through a hand-wrist X-ray.

The results and its discussion will be presented by grade level and a comparison will be made between genders and among grades. Subsequently the study limitations as well as considerations and recommendations for future research and professional intervention will be analyzed. Finally, the conclusions will be presented, as an answer to the formulated hypotheses.

CHAPTER 1. LITERATURE REVIEW

Body composition and Obesity

The end of the past century revealed obesity as a major health issue. It is estimated that it will become one of the largest problems of the XXI century, translating into an increased risk of morbidity and mortality (Carmo, Camolas, & Vieira, 2008).

The definition of overweight and obesity is closely related to the chosen cut-off values. The Centers for Disease Control and Prevention (CDC), based on third National Health and Nutrition Examination Survey (NHANES III), and the International Obesity Task Force (IOTF) defined different BMI cut-off values for children and adolescents based on different study samples. The CDC's study sample is solely American (Kuckmarski et al., 2000) while IOTF's international (Cole, Belizzi, & Dietz, 2000). Furthermore, analyzing the studies on overweight/obesity of Portuguese children/adolescents, it becomes clear that Cole's cut-off values is the main reference (Ekelund et al., 2004a; Padez, Mourão, Moreira, & Rosado, 2005; Moreira, 2007). In fact, the prevalence of overweight/obesity in Portuguese children and adolescents aged 10 to 18 is 21,6% for girls and 23,5% for boys according to the IOTF but present higher values according to the WHO (World Health Organization): 32,7% for girls and 30,7% for boys, i.e. 1/3 of Portuguese children and adolescents are at risk (Sardinha et al., 2010). A meta-analysis of Portuguese children and adolescents, ranging between two and fifteen years old, had similar results in Portugal mainland and its archipelagos (Moreira, 2007). When compared to other European countries, Portuguese children aged seven to nine years old, show higher prevalence of overweight/obesity (31,6%) (Padez et al., 2005).

Additionally, in a study sample composed by Scottish children, the prevalence of overweight was similar for both genders whereas the prevalence of obesity was higher between boys than girls (Veugelers & Fitzgerald, 2005).

Regarding this worldwide health problem and its possible causes, several issues were raised and many studies have been developed to help understand it. The primary causes of obesity in children/adolescents seem to be related to low activity levels and inadequate nutrition (Sothern & Gordon, 2003, as cited in Moreira, 2007). Padez et al. (2005) found that there was no significant difference in the time spent on Physical Activity (PA) and overweight/obesity in Portuguese children as well as mean energy intake, although the

assessment method was a parents' questionnaire. Parental obesity, low educational level, number of siblings and sedentary behaviours (e.g.: watching TV) are some of risk factors for childhood obesity. Otherwise, sleep hours may provide a protective role in this matter (Padez et al., 2005; Veugelers et al., 2005).

The body composition changes as of obesity consequence affects the children's growth. The obese children/adolescents reported musculoskeletal pain, particularly in lower extremities, and alterations of their structure and function (Wearing, Hennig, Byrne, Steele, & Hills, 2006; Stovitz, Pardee, Vasquez, Duval, & Schwimmer, 2008; Grau et al., 2009; Krul, Wouden, Schellevis, Suijlekom-Smit, & Koes, 2009). A study that covered the Akwesasne Mohawk people, a Native American community, concluded that environmental forces (e.g.: pollutants) might affect human growth and development, with obvious health consequences leading to leading to the problems related with overweight/obesity (Schell, Gallo, & Ravenscroft, 2009).

Veugelers & Fitzgerald (2005) verified that the participation in PA more than seven times a week was associated with a decreased risk of overweight in children. To achieve the various components of health-related fitness, school-age youth should participate daily in 60 minutes or more of moderate to vigorous PA (MVPA) (Strong et al., 2005). Baptista et al. (2011) found that only 36% of the Portuguese children (aged ten to eleven) and Portuguese adolescents (aged sixteen to seventeen) fulfilled these guidelines.

Body composition assessment

The available methods for body composition assessment include: anthropometry, densitometry (e.g.: hydrodensitometry), isotope dilution (e.g.: deuterium oxide), bioelectric (e.g.: bioelectrical impedance analyzers), potassium-40, absorptiometry (e.g.: dual X-ray absorptiometry), neutron activation and computerized axial tomography (Zemel, 2002). Therefore, each method needs to be evaluated in the context of the study, in order to choose the method that best fits its purpose.

On an anthropometric characteristics analysis a variation between genders is observable, for example Jürimäe & Jürimäe (2000) observed that before puberty the body fat is maintained in boys and slightly increases in girls. Thus, as the subcutaneous fat is higher in prepubertal girls they have higher values for skinfolds in comparison to prepubertal boys. Taylor, Jones, Williams, & Goulding (2000) reported that the waist circumference is

an anthropometric of regional fat distribution indicator better than ratios, once it is highly age dependent (Power et al., as cited in Taylor et al., 2000) and the differences in skeletal structure may confound the results (Ley et al., 1992 as cited in Taylor et al., 2000). The lower body circumferences tend to be similar between genders during prepuberty, however the trunk circumferences tend to varies between genders, since the robustness is higher in prepubertal boys than girls (Jürimäe & Jürimäe, 2000).

Physical Activity Assessment

The assessing of PA can be accomplished by subjective or/and objective methods. The subjective methods most commonly used in youth are questionnaires, activity diaries (logs), interviews and direct observation. For objective measurements, the most commonly methods used are pedometers, accelerometers and heart rate monitors (Corder, Ekelund, Steele, Wareham, & Brage, 2008).

Among the subjective methods, the interview-administered produced higher validity than the questionnaires and direct observation, but the investigators can opt to undertake questionnaires monitored by an adult to check their completion (Corder et al., 2008).

For adolescents the most widely accepted questionnaires are the “Health Behaviour in Schoolchildren” from the World Health Organization (WHO-HBSC) and the “International Physical Activity Questionnaire” (IPAQ), both validated to an age range between 13 to 18 (Rangul, Holmen, Kurtze, Cuypers, & Midthjell, 2008). These authors also concluded that none of the questionnaires seems to be a valid instrument for the PA assessment in adolescents. Hereupon, another questionnaire that assesses the PA patterns in children and adolescents aged 8 to 16 years and proved to be a valid and reliable instrument is the QAPACE questionnaire (Quantification de l’Activité en Altitude chez les Enfants), that covers all the possible activities conducted by youth during the school and vacation periods (Barbosa et al., 2007).

The accuracy of the subjective methods is lower than the objective methods, as it is dependent of the ability to recall certain details retrospectively (Corder et al., 2008; Freedson, Melanson, & Sirard, 1998) and this ability is obviously lower in children/adolescents than in adults (Corder et al., 2008), thus it is crucial that the questionnaires composed by specific closed questions includes all the available PA patterns (Freedson et al., 1998).

The estimation of energy expenditure (EE) in adults based on self-reports uses the MET (metabolic equivalent) as the ratio of work metabolic rate to a standard resting metabolic rate (1 MET/4,2 kj•kg-1•h-1/1 kcal•kg-1•h-1) obtained during quiet sitting (Ridley & Olds, 2008; Ainsworth et al., 2010). On this matter, a Compendium of Physical Activities for adults (1993) was developed and posteriorly updated in 2010, aiming to facilitate the coding of physical activities obtained from subjective methods, and to promote its comparison (Ainsworth et al., 2010). The estimated METs for adults can be used (if no others evaluations available) to assign the childrens energy costs in most activities (Ridley & Olds, 2008). However the children have higher values in resting and activity EE compared to adults, which leads to an inaccuracy in the estimate of EE in children, at least up girls reaches fifteen years and boys reaches seventeen years (Harrell et al., 2003). The same author asserts that the Compendium of Physical Activities can be used in children but the corrected values must to be used when available.

Among objective methods to assess PA, the pedometers are usually used in large samples but as the output is expressed in steps per day, this method might be a potential confounder in certain types of activities. In activities as cycling or hill walking, the use of heart rate monitor can be considered, once accelerometers have lower accuracy. However, comparing with others objective methods for free-living conditions, the accelerometers have some advantages: are not invasive, have moderate dimensions, and it can assess the total daily PA, their intensity, frequency and duration, therefore is the most commonly used method to assess PA in youth (Corder et al., 2008).

The accelerometers are small devices with light weight and relatively low cost (Trost et al, 1998). These are feasible alternatives to the traditional self-report methods in moderately sized surveillance studies (Trost et al., 2002), evaluating both quantity as quality in physical activity. They also have large memory storage, and the small size it makes them particularly appealing for use in children (Freedson, Pober, & Janz, 2005).

The Computer Science Actigraph (CSA) monitors measures the movement in the vertical plane and were validated as an objective measure for assessing PA in children and adolescents (Trost et al., 1998; Freedson et al., 1998). The CSA monitors proved to be highly correlated with indirect calorimetry and exhibited a high degree inter-instrument reliability, making them a valid and reliable device for quantifying the walking and running patterns in a treadmill, in children aged ten to fourteen years old (Trost et al., 1998). The Mini-Mitter Actiwatch and the CSA monitors have proved to be valid and useful instruments for the assessment of children's PA, given the high correlations between them

and the activity EE measured by more accurate methods (Puyau, Adolph, Vohra, & Butte, 2002).

However, before using these devices, the investigative team has to analyze some issues (Trost, Mciver, & Pate, 2005) such as: which accelerometer to choose, how many devices per child, where to place them in the body to obtain reliable values, how many days of monitoring, and the epoch length.

Analyzing the accelerometers it might be probable, at first sight, to opt for tri-axial one. Actually, these provide better evaluations, but the difference it is not so significant. A review about accelerometers validation stated that over a range of free-living activities, both uni-axial as tri-axial accelerometers provide similar information about children´s PA (Trost et al., 2005; Freedson et al., 2005). Using multiple accelerometers may slightly improve the prediction of EE during the treadmill walking and running (Trost et al., 1998) but these improvements did not exceed the burden associated of wearing multiple accelerometers (Trost et al., 1998; Trost et al., 2005).

Where to place accelerometers to reach reliable values? Placing them in the center of the body seems to be an optimal choice (Puyau et al., 2002). Typically they are worn on the wrist, lower leg or hip, where they are attached to a belt or band (Freedson et al. 2005). The hip and lower back proved to be the better choices (Trost et al., 2005) however, with CSA monitors the hip is the most suitable choice (Trost et al., 1998; Puyau et al., 2002).

Concerning the days of monitoring in children and adolescents, it requires ranges from four to nine days, being seven days a more reasonable choice (Trost et al., 2005), but the adherence to the protocol tends to decrease when increases the days of use and it is more feasible to opt for four days including one weekend day (Riddoch et al., 2004; Corder et al., 2008), with a minimum of six hundred minutes of recording per day or ten hours (Corder et al., 2008).

Due to the short duration of some activities the epoch length should be as short as possible, since data can be reintegrated into a longer timeframe but not vice versa (Corder et al., 2008) and this is especially important in prepubertal children because they typically perform intermittent activities and a one minute time interval (used in the majority of the studies) can underestimate the PA behaviours (Trost et al., 2005; Corder et al., 2008).

Self-report instruments and movement sensors are currently the more commonly used methods for the assessment of PA in epidemiological studies (Corder et al., 2008).

Physical Activity Intensities

The acknowledgment of that the PA decreases with increasing of the Chronological Age (CA) from the late childhood until adolescence in both genders and that exist differences between genders, with boys being more active than girls, are consistent with several studies to date (Mechelen, Twisk, Post, Snel, & Kemper, 2000; Trost et al., 2002; Thompson, Baxter-Jones, Mirwald, & Bailey, 2003; Riddoch et al., 2004; Ekelund, Ingve, Brage, Westerterp, & Sjöström, 2004b; Sherar, Esliger, Baxter-Jones, & Tremblay, 2007). This can be observed across all grade levels (Trost et al., 2002) and across countries (Riddoch et al., 2004). Likewise, PA assessed by VO_2 showed decline with an increase in age (Harrell et al., 2003; Baptista et al., 2011).

A study performed among Portuguese children and adolescents, aged 10 to 18 years, in which PA was evaluated by self-report method, boys showed higher values of PA than girls, however this study produced discrepant results compared with those aforementioned because the levels of PA increased with age (Seabra et al., 2008).

It is noteworthy that occurs a greater decline in PA in boys than in girls, however a closer look in the mentioned study from Mechelen et al. (2000), a longitudinal analysis that began at age 13 and ended at age 27, the decline in PA might be due to the fact that at the beginning of this study the girls were much more active than boys, providing a greater decreases in the amount and level of PA. However the effect of the gender might not be significant if the fat-free mass was considered as a co-variable (Ekelund et al., 2004a).

The PA assessed by RAPIL questionnaire (Anthropometric Re-evaluation of the Infantile Lisbon Population) revealed lowest levels of high intensity PA (less than 105 minutes) in girls than boys (Fragoso, Bronzeado, Vieira, & Barrigas, 2009). Girls spend more time in physical activities of low intensity (over 60 minutes) and has a higher daily commitment to domestic activities, while the boys spend more time in regular and non-regular PA and more frequently get involved in PA of high intensity. The total time spend on activity is similar for boys and girls (Fragoso et al., 2009).

Distinguishing the PA levels performed by children and adolescents assessed by accelerometry, it is possible to obtain some consistencies and also some discrepancies.

Relatively to sedentary behaviours, girls spend significantly more time at this level of intensity than boys and was positively correlated with the sum of five skinfold thickness

(Ekelund et al., 2004a). More than one hour per day in this intensity level was positively associated with the risk of overweight (Veugelers & Fitzgerald, 2005).

At MPA the girls showed higher results than boys (Mechelen et al., 2000), but Riddoch et al. (2004) and Rodrigues et al. (2010) obtained inverse results at this intensity level. Trost et al. (2002) did not found significantly differences between genders at this intensity level.

Independent associations were observed in the PA on body fatness variables: when body fatness was defined as BMI there was no association between PA and body fatness, suggesting that BMI may not be the best indicator in children, however when the aforementioned indicator was defined as five skinfold thickness, the Moderate-to Vigorous Physical Activity (MVPA) explained a small variation of this indicator (Ekelund et al., 2004a). Furthermore, the study location, gender and sexual maturity explained 24% of the variation in body fatness (Ekelund et al., 2004b).

The gender differences are greater in the VPA than in the MVPA (Sherar et al., 2007; Trost et al., 2002), which can be due to low participation in vigorous activities by girls (Trost et al., 2002). However, Mechelen et al. (2000) did not found gender differences at vigorous level.

For both genders, daily MVPA and VPA had an inverse relationship with grade level (Trost et al., 2002). Very Vigorous Physical Activity (VVPA) was performed by boys more than by girls until 16 years, past this age the differences did not remain (Mechelen et al., 2000).

The hours spend watching television was related to the skinfold thickness and the BMI among youth, since children who watched more television and were less likely to participate in vigorous activity tended to have a greater BMI (Andersen, Crespo, Bartlett, Cheskin, & Pratt, 1998). However it is important to highlight the fact that children who accumulated two or more hours per day, at an intensity level equivalent to walking, had significantly lower skinfold thickness than those who spent less than one hour per day at the same intensity level, suggesting that time spent in PA should be taken into consideration and not just the intensity of it (Ekelund et al., 2004b).

Growth and biological maturation

To understand the main factors that influencing development in prepubertal children is essential clarify some issues. The growth and maturation terms can be easily confounded

because both are biological activities, however they have different meanings. Growth is related to measurable changes in body composition, physique and body size, and maturation is related to somatic, endocrinological and physiological manifestations (Jürimäe & Jürimäe, 2000). Maturation and maturity has also different meanings: maturation (or biological maturation) refers to a process (relates biological time to calendar time) whereas maturity refers to a state.

However, the path to reaches the maturity varies among individuals (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). Children and adolescents with the same CA present considerable variations in biological age and the maturity individual differences affect the somatic growth, especially in adolescence (Malina, Bouchard, & Bar-Or, 2004). Thereby, since boys and girls reach maturational events at different tempos (Sherar, Baxter-Jones, & Mirwald, 2004), CA is considered a poor marker, given the disparity of characteristics among children in the same CA (Jürimäe & Jürimäe, 2000).

Maturation Assessment Methods

The assessment of biological maturation might include sexual, somatic, dental and skeletal systems (Tanner, 1962; Jürimäe & Jürimäe, 2000; Thompson et al., 2003; Malina, 2004).

To assess the sexual maturation is often used the secondary sex characteristics, in which the most commonly variables used are: pubic hair in both genders, breast development and menarche in girls, and genitals development in boys. The indicators were classified in five or six stages (Tanner, 1962). Moreover, there are others maturity indicators that can be used as: axillary hair (both genders), voice change and facial hair in boys (outward indicators) and level of sex hormones in the blood (inward indicator) (Malina et al., 2004). However, the assessment of secondary sexual characteristics is limited to pubertal phase and, in a nonclinical situation, is considered to be personally intrusive by adolescent children and their parents (Beunen et al., 1997; Mirwald et al., 2002; Malina et al., 2004).

The somatic maturity level can be assessed by growth curve for stature (if stature is available) or percentage of adult stature attained (if adult stature is available). The two main variables of the growth curve for stature were: age at takeoff (onset of the growth spurt) and age at PHV (Peak Stature Velocity). The methods used for predicting adult stature are: Bailey-Pinneau, Roche-Wainer-Thissen and Tanner-Whitehouse (Malina et

al., 2004). Furthermore, a noninvasive method was developed to predict the years from PHV by using anthropometric values, using leg length to sitting stature ratio to predict maturity status (Mirwald et al., 2002).

The dental maturity level can be assessed by X-ray, where each tooth has specific stages with a score system assigned to each stage. The indicator of dental maturity is the sum of scores.

The skeletal age (SA) assessment is considered the best maturational index, however is costly, requires specialized equipment and interpretation and incurs radiation safety issues (Beunen et al., 1997; Mirwald et al., 2002; Sherar et al., 2004; Malina et al., 2004). The left hand-wrist X-ray is the best method to assess skeletal maturity and determine biological age, because this area contains multiple bones and it's able to characterize the skeleton maturation as a whole (Jürimäe & Jürimäe, 2000; Malina et al., 2004).

The three methods commonly used for the assessment of skeletal maturity of the left hand-wrist X-ray are: Greulich-Pyle, Tanner-Whitehouse and Fels methods (Malina et al., 2004). The methods differ in criteria for making assessments and in procedures to construct a scale of skeletal maturity (Malina et al., 2004), however the Tanner-Whitehouse method (TW3) is currently the most widely accept (Tanner, Healy, Goldstein, & Cameron, 2001). This method was revised and underwent to some modifications, including a broader reference sample (not only British children), some changes made at the scoring system and others to the scale for converting the skeletal maturity to an SA (Malina et al., 2004). The TW3 method assesses the seven carpal bones (excluding pisiform) and thirteen long bones (radius, ulna, metacarpals and phalanges of the first, third and fifth digits). A specific point score is assigned to each bone and the scores are summed to give a skeletal maturity score, which ranges 0 (immaturity) to 1 (maturity) (Malina et al., 2004). Thereafter, the SA is expressed relative to the CA, i.e., the difference between SA and CA provides how much the children/adolescent is advanced (early) or delayed (late) (Malina et al., 2004) and to avoid misunderstandings this difference can be defined as relative SA . Thus, if the relative SA is delayed by more than a year from the CA the children are classified as late maturers and if is advanced by more than one year the children is classified as early maturers (Jürimäe & Jürimäe, 2000; Malina et al., 2004).

In subjects with early maturity levels, the growth spurt occurs earlier, meaning that during a period of approximately two years, these subjects become disproportionate (short trunk and long limbs) and have generalized hypotonic and the muscles do not follow the skeletal growth (Vieira & Fragoso, 2006) and it should be pointed out that the

children/adolescents that are considered early matures have advantage in motor abilities during prepubertal years comparing with their pears late matures, however this difference vanishes in later years (Jürimäe & Jürimäe, 2000).

The percentage of adult stature calculated with Tanner-Whithouse method is an efficient maturity indicator and can be used in a variety of settings as a noninvasive substitute for skeletal maturation (Beunen et al., 1997). Sherar et al. (2004) suggest that considering the gender differences in timing and tempo during adolescence, the secondary sex characteristics was an inappropriate assessment for gender comparisons whilst assessment of somatic maturation is more feasible (e.g. age at PHV).

In summary, the variables of skeletal, sexual and somatic maturity are positively related to each other, but dental maturity tends to proceed independently (Jürimäe & Jürimäe, 2000; Malina et al., 2004).

Physical Activity and Maturation

The adolescents experience dramatic physiological changes which probably influence the participation in PA (Erlandson et al., 2011). Thus, some authors support the idea that all studies on adolescents require control for the confounding effects of maturation (Mirwald et al., 2002; Cumming, Standage, Gillison, & Malina, 2008). Aligning PA data by biological age in adolescence improve the PA tracking, especially in girls (Erlandson et al., 2011).

As aforementioned (in physical activity levels and body composition), the PA levels in children and adolescents decrease with the increasing CA and when aligned on biological age the results remains, being significant and negatively correlated with PA (Thompson et al., 2003). As in matter of fact the maturation is positively correlated with sedentary behaviour and negatively correlated with PA (Rodrigues et al., 2010) and also has been found that the exercise during early pubertal years has the greatest impact on bone accrual in girls (Völgyi et al., 2010).

An interesting finding is that children and adolescents (Estonian and Swedish sample) that sleep more than ten hours spend more time on PA (all intensities) and less time on sedentary activities than those that sleep fewer hours, however when adjusted for age and sexual maturation (Tanner stages) these associations have become non-significant (Ortega et al., 2011).

In a review across biological maturation and PA in adolescents found no differences in self-report PA among girls early, average and late maturers, similar results are accomplished between pedometers steps and maturity status and between accelerometers and breast development (Sherar, Cumming, Eisemann, Baxter-Jones, & Malina, 2010). Similarly, the participation in MVPA by girls early and late maturers did not show any differences. Early maturers girls' in the 7th grade reported more time in sedentary behaviours than late maturers girls, which is not seen in the 8th, 9th and 10th grades. Some authors found no association between maturity status and the self-reported VPA, while others found that early matures girls participated in less MVPA and VPA (Sherar et al., 2010). PA per day (assessed by pedometry) did not differ among boys early, average and late maturers. Self-report PA was inversely related to the time spent in MVPA and was not correlated to biological age (assessed by pubertal development). The early matures boys were associated with higher levels of self-reported VPA and also with higher levels of sedentary behaviours than the late maturers (Sherar et al., 2010).

It should also be taken into consideration the confounding effects of biological age to fully understand the gender disparities in PA, because these differences can be due to the early maturation of the girls, i.e, on average girls mature earlier than boys and when comparing PA levels between genders for the same CA, the PA levels in girls presents a higher overthrow (Sherar et al., 2007). In this matter some authors found that the significant gender disparities observed with CA were eliminated when the data were aligned with the biological age (Thompson et al., 2003; Rodrigues et al., 2010).

Analysing the light forms of PA the difference between genders is not very pronounced, what can be explained by the increased on average daily time spent in sedentary behaviours in both genders (Sherar et al., 2007; Rodrigues et al., 2010), although girls spend significantly more time in sedentary behaviours than boys, especially on weekdays (Rodrigues et al., 2010). Somatic maturation (assessed by the percentage of estimated adult stature) explained 5% of the variance in sedentary behaviours in boys and CA and the body mass explained 12% of the variance in sedentary behaviours in girls. Somatic maturation and CA explained 8% of the variance in LPA in boys however for girls any of the chosen variables explained the variance in LPA (Rodrigues et al., 2010).

Furthermore, looking to the time spent in MVPA a decrease is noted in adolescents with the increase on age in both genders and between genders the boys spent more time in MVPA than girls (as above stated in physical activity levels and body composition), although nearly all of these studies have not considered the maturity status, and if aligned

with biological age the sex differences in time spent in MVPA can disappears (Sherar et al., 2007), however Rodrigues et al. (2010) found that the CA and somatic maturation explained 30% of the MVPA in boys and the CA and body mass explained 20% of the MVPA in girls.

Analysing the maturity difference between genders on PA (assessed by questionnaire) has been proved that maturity only influences the variability of domestic activities (Fragoso et al., 2009) and the anthropometric variables are dependent on the maturity level however PA (with exception of the domestic activities and the sedentary behaviours) appears to be independent of the maturational variability (Fragoso et al., 2009).

In summary, biological maturation refers to a process with differences in timing and tempo and may contribute to the gender disparities in PA behaviors, however it is likely that this process in combination with social, psychosocial, physical and physiological changes underlie the observations rather than the maturity status *per si* (Rodrigues et al., 2010). The inconsistent findings between maturation and PA may be due to the assessment methods selected for both (Sherar et al., 2010).

PA and Maturation effects on Body Composition

Is expectable that PA improve the morphological characteristics in children and also contributes to a normal growth and development. Investigation to date shows that the amount of MVPA is a significant predictor of aerobic fitness in prepubertal children (Jürimäe & Jürimäe, 2000), however the interaction among anthropometric variables, PA and maturation needs a further look.

The central feature of human puberty is the maturation of the primary reproductive endocrine axis, comprising three parts: hypothalamus, pituitary gland and gonad, usually called HPG axis. This produced many modifications in individuals, namely on body composition. Significant changes in body composition occur during puberty in both genders, with boys increasing in free-fat mass percentage and girls in fat mass (FM) percentage, which is consequence of increased production of gonadal steroids. As in matter of fact the increase in gonadal estrogen production in girls leading to increases in FM percentage after menarche (Ellison, 2002). A longitudinal analysis found significant increases in FM in girls during the first year after menarche, pointing for the fact that puberty is of influence on FM (Vink et al., 2010).

In boys the increases in muscle mass that accompany puberty is due to the anabolic effects of gonadal testosterone (Ellison, 2002). A longitudinal analysis in the role of PA in the free-fat mass with maturation status controlled (Baxter-Jones, Eisenmann, Mirwald, Faulkner, & Bailey, 2008) concludes that the muscle development is driven in part by PA, however this increase is higher in boys than girls. Furthermore, positive associations (only for the lower body) were found between VPA and muscular strength on adolescent boys but not in girls, controlling for age, maturation status and free-fat mass (Moliner-Urdiales et al., 2010).

CHAPTER 2. OBJECTIVES AND HYPOTHESES

The present thesis presents a cross-sectional study designed with the main purpose of analyse the effects of maturation and PA, assessed through subjective and objective methods, on adolescents' body composition between 12 and 16 years old.

2.1. General objective

Establish the associations of the PA in the adolescents' body composition, controlling for the maturation status.

2.2. Specific objectives

- To compare the maturity status, between boys and girls, stratified by grade level;
- To compare the body composition between boys and girls, stratified by grade level;
- To compare the Daily Energy Expenditure (DEE) in PA, assessed by questionnaire, between boys and girls, stratified by grade level;
- To compare the time spent in PA, assessed by accelerometry, between boys and girls, stratified by grade level;
- Identify the associations between the body composition variables and the DEE and time spent in PA controlling for the maturity status.

2.3. Hypotheses

- The maturity status is highest in the girls when compared to boys across all the grade levels;
- The body composition variables are highest in girls compared to boys across all the grade levels, with the exception of the waist-to-hip ratio;

- The PA levels are higher in the boys than in girls, irrespective of grade level;
- The PA levels decreases with increasing age for both genders;
- Adolescents with higher values of total PA are prone to lower values in the body composition variable in both genders;
- Adolescents with higher values of MVPA are prone to lower values in the body composition variable in both genders;
- Adolescents with an advance in maturity status present higher values in the body composition variable;
- Adolescents with a delay in maturity status present lowest levels of PA.

CHAPTER 3. METHODS AND PROCEDURES

3.1. Study design

A cross sectional survey was conducted involving two public schools in Lisbon's surrounding area: Miraflores Secondary School and José Augusto Lucas Secondary School.

This study was approved by the scientific council of Faculty of Human Kinetics and by both school directors and physical education department's coordinators.

Thereafter was scheduled a meeting with the physical education department's coordinator and the subjects' parents, where objectives of the study and their methodology were presented. The informed consents were distributed to parents (see appendix 1) and the study began after the commitments had been given.

Following will be described the variables operationalization and the study phases.

3.1.1. Variables operationalization

The variables were grouped by subject as described below:

- *Maturity status* - Chronological Age (CA), Skeletal Age (SA), Difference between Skeletal Age and Chronological Age (Relative SA); it is important to highlight the fact that CA is not a maturity indicator, nevertheless it will be placed in this group once that it was used to estimate the SA value.
- *Body Composition (BC)* - Body Mass Index (BMI), Fat Mass (FM), Sagittal-Abdominal Diameter (SAD), Waist-Hip Ratio (WHR).
- *Physical Activity (PA)* - assessed per questionnaire (thirteen categories, total DEE) and per accelerometry [Sedentary / Active; Light Physical Activity (LPA); Moderate Physical Activity (MPA); Vigorous Physical Activity (VPA); Very Vigorous Physical Activity (VVPA); Moderate-to-Vigorous Physical Activity (MVPA); Total Vigorous Physical Activity (TVPA)].

Table 1: Operationalization plan

Kinds of Variables	Variables		Types of variables	Collection method
Dependent variables	Body Composition (BC)	Body mass index (BMI)	Continuous quantitative	Anthropometric measurements
		Fat mass (FM)		
		Waist-hip ratio (WHR)		
		Sagittal-abdominal diameter (SAD)		
Independent variables	Physical Activity (PA)	Daily Energy Expenditure (DEE)		Questionnaire
		Time spent in PA (min)		Accelerometry
Co-variables	Maturity status	Chronological age (CA)		---
		Skeletal age (SA)		Hand-wrist x-ray
		Difference between skeletal age and chronological age (Relative SA)		---

3.1.2. Study phases

The study took place in several stages. The first stage was the literature review, followed by the data collecting process that occurred between January and May of 2011 and constituted four phases of the study. The data processing was organized by the three following phases, and finally the outcome analysis and findings' discussion were the last phases.

Table 2: Study phases

Study phases	School year 2010/2011												
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Theory background													
Anthropometric data collection													
Questionnaire application													
Accelerometers application													
Hand-wrist x-ray's data collection													
Anthropometric data processing													
Questionnaire data processing													
Hand-wrist x-ray's data processing													
Outcome analysis													
Discussion and conclusions													
Last review and formatting													

3.2. Study sample

The study sample comprised adolescents of the secondary grade (7^{th}, 8^{th} and 9^{th} grades) and the total sample comprised 180 students (stratified random sampling), including both boys and girls, mainly white and without disabilities.

3.3. Instruments and procedures

The methodology included subjective and objective measurements: anthropometric measurements, hand-wrist X-ray and PA assessment (per questionnaire and accelerometry). The instruments used in measurements and the performed procedures will be described in detail.

3.3.1. Maturity assessment methods

Two variables were used to ascertain adolescents' maturity status: Skeletal Age (SA) and the Difference between SA and CA (Relative SA).

The SA was assessed through an X-ray of the left hand and wrist, with a portable X-ray equipment, model Ascot 110 and Kodak Min-R films. The SA was determinate through the TW3 method (Tanner et al., 2001).

The Chronological Age (CA) was used to calculate the Relative SA inasmuch this indicator expressed the difference between the SA and CA. However, CA is not considered a maturity indicator. All the obtained values were expressed in years.

3.3.2. Body composition assessment methods

The anthropometric measurements were obtained by certified anthropometrists according to the International Society for the Advancement of Kinanthropometry (ISAK) standard procedures (Marfell-Jones, Olds, Stewart, & Carter, 2006), with the exception of the

Sagittal-Abdominal Diameter (SAD). The measurements were taken on the right side of the body, at an acclimatized room, where adolescent's privacy was guaranteed.
This stage ran during the physical education classes, where adolescents were divided in small groups, by gender. During measurements the participants wore shorts and t-shirt or top, all jewelry was removed as well as shoes, however socks were allowed.

The measurements used were: stature; body weight; skinfold thickness, namely triceps (TRI), subscapular (SBS), and medial calf (CALF); waist and hip girths; and sagittal-abdominal diameter.

Anthropometric variables were obtained using the DKSH (previous Siber-Hegner GPM) Kit; a Rosscraft measurement tape; a Slimguide skinfold caliper; and a Seca Vogel & Halke Balance, model 761 7019009.

The body composition variable was composed by the following variables:

1- Fat Mass (%), estimated through the Slaughter et al. (1988):

$$\% FM = 0.735 (TRI + CALF) + 1.0 \text{ (boys)}$$

$$\% FM = 0.610 (TRI + SBS) + 5.1 \text{ (girls)};$$

2- Sagittal-Abdominal Diameter (cm), that is the distance between the abdomen and the back, measured in the standing position at the iliacrest level at the end of normal expiration;

3- Body Mass Index: BMI (kg/m^2) = weight (kg) / stature (m^2);

4- Waist to Hip Ratio: WHR = waist girth (cm) / hip girth (cm).

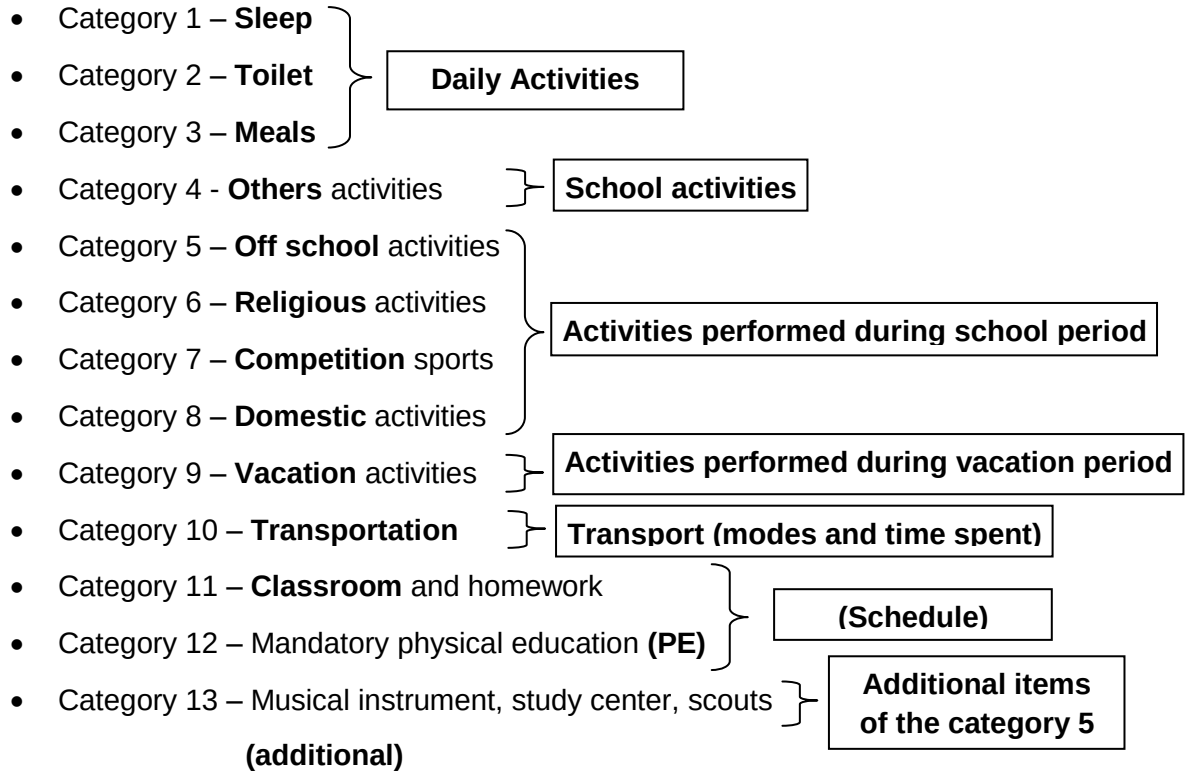
3.3.3. PA assessment methods

3.3.3.1. QAPACE questionnaire

The selected questionnaire to assess PA is named QAPACE - Quantification de l'Activité Physique en Altitude Chez les Enfants, and was recently designed and validated for a range of ages between 8 and 16 years old (Barbosa et al., 2007). This questionnaire was developed in English language and aims to quantify the levels of PA covering all the daily activities within school and vacation periods. The questionnaire is composed by closed

answers, for data accuracy purposes given the range of ages. Another advantage of this questionnaire is a detailed characterization of each activity in terms of type, duration and frequency, allowing the definition of PA patterns.

The questionnaire used resulted from an adaptation for the cultural and Portuguese language (see appendix 2) and remains in validation process, thereby this process will not be presented in this document once it doesn't match the study purpose. Furthermore, in order to properly organize the outcome analysis the categories were organized as following describes:



As aforementioned the questionnaire is in validation process, some items were organized to achieve this goal. The DEE calculations in the category 5 did not include all the questions presented in the questionnaire, once they have been considered in further categories. The category 11 was estimated by the summing of the total time spent in homework (presented in the category 5) and the time in classroom (presented in the schedule). The category 12 was calculated taking into account the total time of physical education classes (presented in the schedule) and the category 13 was the sum of the

items (described above) that have been added to the category 5. Therefore, the categories 11, 12 and 13 do not appear in the questionnaire.

The questionnaire was self-administered, however the questions were read out loud by two team researchers that have oversaw the entire process. Their presence aimed to clarify questions, which minimized biases. The time needed to fulfill the questionnaire was 30 minutes, which it is the recommended for not exceed the mental concentration capacity of the children/adolescents (Barbosa et al., 2007). The DEE was measured summing the total of METs spent in each activity item of the questionnaire (Ainsworth et al., 2010).

3.3.3.2. Accelerometry

The PA was objectively assessed using a uniaxial accelerometer, Actigraph (GTM1 model, Fort Walton Beach, FL, USA) (Trost et al., 1998; Freedson et al., 1998), with the following dimensions: 5,3x5,1x2,2 cm. The accelerometers were initialized as described by the manufacturer (with the ActiLife Lifestyle software, version 3.2) and were distributed and collected face-to-face by the investigation team. The adolescents were instructed to use them on right hip (as close as possible to the body's center of mass) (Puyau et al., 2002) and the PA was monitored continuously for seven consecutive days (Trost et al., 2005).

The accelerometers are not water resistant, hence it have to be removed during all aquatic activities (e.g. bathing, swimming), and also during sleep. For data accuracy and to provide information about the physical activity performed (or any other information), while the monitor was not worn, they had to register simultaneously in the non-wear activity diary, the time at which the accelerometer it was placed and removed during the seven days. After that week the accelerometers were collected and data were downloaded for a computer with the ActiLife Fifestyle software, and the Mahuffe program was used for the data analysis.

The data were considered to be valid if the adolescents had accelerometer counts for at least three weekdays, minimum of ten hours of recording (including one day in the weekend with eight hours of recording) (Trost et al., 2005; Riddoch et al., 2004; Corder et al., 2008), giving a total of 600 minutes per day. Data were saved in 15-s epoch in accordance with some authors (Trost et al., 2005; Corder et al., 2008), which corresponds

to the time interval that the accelerometer has collected information (each 15 seconds). Consecutive values of zero that lasted sixty minutes were considered as non-wearing.

The Freedson prediction equation of energy expenditure, validated in children and adolescents aged 6 to 18 years old, was used to estimate Metabolic Equivalent (METs) from the count values: $MET = 2.757 + (0.0015 \cdot count \cdot min^{-1}) - (0.08957 \cdot age(yr)) - (0.000038 \cdot counts \cdot min^{-1} \cdot age(yr))$, as cited in Trost et al. (2002).

3.4. Statistical Analysis

Data were analyzed with SPSS version 18.0 (SPSS Inc., an IBM Company, Chicago). Data treatment was performed by descriptive analysis for all the variables, initially performed by absolute and relative frequencies of each group of variables and later through central tendency for each variable. The results were presented by gender and grade level, showing the mean, median and both lower and upper boundaries of a 95% confidence interval. The Shapiro-Wilk test and the Levene's test were performed in order to ensure parametric characteristics ($n<50$). To compare average values was performed t-student test for parametric variables and, in alternative, Mann-Whitney and Wilcoxon test for non-parametric variables. The Spearman's correlation coefficient was performed between the PA and maturity variables with the body composition variables. For all tests statistical significance was set at $\rho<0,05$.

Multifactorial linear regression models were subsequently performed to predict the value of a dependent variable (or outcome) from an independent set of variables (or predictors) (Maroco, 2010), controlling for the maturity. Stepwise method was applied for association tests, since it is the most appropriate when there are significant correlations between independent variables (Maroco, 2010). Thus, four regression model equations were developed, stratified by gender and grade level. Adjusted r^2 was used to define the model adjustment quality.

CHAPTER 4. RESULTS

The sample comprised 180 adolescents, with distinct frequencies for each group of variables (valid data). Therefore, sample description is displayed in two different tables, illustrating the absolute and relative frequencies (n, %). Is presented firstly is the general sample description, stratified by gender and grade level (Table 3) followed by the group variables description (Table 4).

Table 3: Sample general description by gender and grade level

	7th grade		8th grade		9th grade		Total	
	N	%	n	%	n	%	n	%
Boys	43	23,9	29	16,1	25	13,9	97	53,9
Girls	32	17,8	25	13,9	26	14,4	83	46,1
Total	75	41,7	54	30	51	28,3	**180**	100%

Table 4: Group variables description by gender and grade level (valid data)

	7th grade				8th grade				9th grade				Total	
	Boys		Girls		Boys		Girls		Boys		Girls			
	n	%	N	%	n	%	n	%	N	%	n	%	n	%
Maturity status	37	86	22	68,8	17	58,6	15	60	9	36	13	50	113	62,8
Body composition	38	88,4	26	81,3	20	69	17	68	15	60	21	80,8	137	76,1
PA per questionnaire	43	100	32	100	29	100	25	100	25	100	26	100	176	100
PA per accelerometry	29	67,4	15	46,9	15	51,7	16	64	7	28	13	50	95	52,8

The sample comprised 75 students of the 7th grade (41,7%), 54 students of the 8th grade (30%) and 51 students of the 9th grade (28,3%), in a total of 180 adolescents of both genders. The average age of 7th grade students was 12,8 years, of 8th grade students was 13,8 years and of 9th grade students was 14,7 years. The percentage values showed a higher discrepancy between genders in students of the 7th grade (14,6% difference for boys), although this difference decreased in the following grades, presenting similar values in students of the 9th grade (49% of boys and 51% of girls) (table 3).

Analyzing each group of variables, it is noted that PA by questionnaire registered 100% of valid data (table 4), i.e., 51 out of 51 students of the 9th grade filled the PA questionnaire (table 3). The body composition variable showed 76,1% of valid data, followed by maturity status with a 62,8% value, finally the PA per accelerometry showed a 52,8% frequency.

4.1. Maturity variables characterization

Descriptive data of maturity status variables will be summarized next, stratified by gender and grade level. It should be pointed out that, despite the CA not being a maturity indicator, it will be included in the maturity group, thus simplifying the outcome analyses. These analyses will be presented per group of variables.

Table 5: Maturity variables as mean, median, standard deviation and the corresponding 95% CI of the 7th grade

7th grade							
	Boys (n=37)			Girls (n=22)			t (ρ-value)
	Mean±SD (median)	95% CI		Mean±SD (median)	95% CI		
		Lower Bound	Upper Bound		Lower Bound	Upper Bound	
CA (years)	12,90±0,93(12,67)	12,59	13,21	12,62±0,42(12,58)	12,43	12,81	371,50(0,58)*
SA (years)	12,38±1,45(12,35)	11,90	12,87	12,68±1,45(12,45)	12,04	13,32	365,00(0,51)*
Relative SA (years)	-0,52±1,18(-0,40)	-0,91	-0,12	0,06±1,31(-0,09)	-0,52	0,64	-1,73(0,09)

*** Mann-Whitney test performed**
Abbreviations: CA – Chronological Age; SA – Skeletal Age; Relative SA - Difference between SA and CA; SD – Standard Deviation; CI – Confidence Interval

Table 6: Maturity variables as mean, median, standard deviation and the corresponding 95% CI of the 8th grade

8th grade							
	Boys (n=17)			Girls (n=15)			U (ρ-value)*
	Mean±SD (median)	95% CI		Mean±SD (median)	95% CI		
		Lower Bound	Upper Bound		Lower Bound	Upper Bound	
CA (years)	13,74±0,62(13,50)	13,41	14,06	13,89±0,63(13,92)	13,55	14,24	101,00(0,32)
SA (years)	12,62±1,75(12,96)	11,72	13,52	15,05±1,31(16,00)	14,33	15,78	32,50**(<0,01)**
Relative SA (years)	-1,11±1,72(-0,85)	-2,00	-0,23	1,16±1,07(1,50)	0,57	1,75	31,00**(<0,01)**

*** Mann-Whitney test performed**
Abbreviations: CA – Chronological Age; SA – Skeletal Age; Relative SA - Difference between SA and CA; SD – Standard Deviation; CI – Confidence Interval

Table 7: Maturity variables as mean, median, standard deviation and the corresponding 95% CI of the 9th grade

9th grade							
	Boys (n=9)			Girls (n=13)			U (ρ-value)*
	Mean±SD (median)	95% CI		Mean±SD (median)	95% CI		
		Lower Bound	Upper Bound		Lower Bound	Upper Bound	
CA (years)	14,76±0,78(14,50)	14,16	15,36	14,68±0,52(14,58)	14,37	14,99	51,50(0,64)
SA (years)	14,94±1,18(14,81)	14,03	15,85	15,82±0,56(16,00)	15,48	16,16	37,00(0,13)
Relative SA (years)	0,18±1,37(0,22)	-0,88	1,24	1,14±0,70(1,42)	0,72	1,57	35,00(0,12)

*** Mann-Whitney test performed**
Abbreviations: CA – Chronological Age; SA – Skeletal Age; Relative SA: Difference between SA and CA; SD – Standard Deviation; CI – Confidence Interval

Boys from the 7th and 9th grades registered higher average CA values than girls (tables 5,7) and girls from the 8th grade registered the highest value for the aforementioned indicator (table 6).

Average SA values were lower in boys across all grade levels (tables 5,6,7), although gender differences only showed statistical significance in the 8th grade (12,62 years vs 15,05 years, p<0,01). Similar results were obtained for the Relative SA indicator (tables 5,6,7), i.e., boys showed a delay in maturity status in comparison to girls and these differences were also statistically significant only for the 8th grade only (-1,11 years vs 1,16 years, p <0,01) (table 6). On a maturity status analysis it should be highlighted that both 7th grade boys and girls of the 7th grade revealed a maturity status within the normal range, as the Relative SA indicator showed a difference lower than one year (-0,52 years vs 0,06 years) (table 5). The 8th grade boys revealed a delayed maturity status, while girls showed an advanced maturity status (-1,11 years vs 1,16 years) (table 6), and in the 9th grade the boys presented a normal maturity status and girls an advanced maturity (0,18 years vs 1,14 years) (table 7).

4.2. Body composition variables characterization

Descriptive data of body composition variables will be summarized next, stratified by gender and grade level.

Table 8: BC variables as mean, median, standard deviation and the corresponding 95% CI of the 7th grade

	7th grade						
	Boys (n=38)			Girls (n=26)			
	Mean±SD (median)	95% CI		Mean±SD (median)	95% CI		U (ρ-value)*
		Lower Bound	Upper Bound		Lower Bound	Upper Bound	
BMI (kg/m²)	19,20±3,11(18,51)	18,18	20,23	20,41±2,41(20,23)	19,43	21,38	341,00**(0,04)**
SAD (cm)	17,28±2,19(16,45)	16,56	18,00	17,68±2,08(17,70)	16,84	18,52	421,00(0,32)
FM (%)	17,04±7,45(14,23)	14,59	19,49	19,35±4,56(19,13)	17,51	21,19	308,00**(0,01)**
WHR	0,82±0,04(0,82)	0,81	0,83	0,78±0,07(0,77)	0,75	0,81	239,00**(<0,01)**

*** Mann-Whitney test performed**
Abbreviations: BC – Body Composition; BMI – Body Mass Index; SAD – Sagittal Abdominal Diameter; FM – Fat Mass; WHR – Waist-to-Hip Ratio; SD – Standard Deviation; CI – Confidence Interval

Table 9: BC variables as mean, median, standard deviation and the corresponding 95% CI of the 8th grade

8th grade							
	Boys (n=20)			Girls (n=17)			
	Mean±SD (median)	95% CI		Mean±SD (median)	95% CI		t (ρ-value)
		Lower Bound	Upper Bound		Lower Bound	Upper Bound	
BMI (kg/m²)	18,55±2,50(18,35)	17,38	19,72	20,03±3,37(19,84)	18,30	21,76	-1,53(0,14)
SAD (cm)	16,99±1,66(17,10)	16,21	17,76	17,39±2,37(17,50)	16,18	18,61	-0,62(0,54)
FM (%)	14,94±6,26(14,41)	12,01	17,87	20,39±6,18(21,27)	17,21	23,56	84,00**(0,01)***
WHR	0,81±0,03(0,81)	0,79	0,83	0,73±0,04(0,73)	0,71	0,75	6,13**(<0,01)**

*** Mann-Whitney test performed**
Abbreviations: BC – Body Composition; BMI – Body Mass Index; SAD – Sagittal Abdominal Diameter; FM – Fat Mass; WHR – Waist-to-Hip Ratio; SD – Standard Deviation; CI – Confidence Interval

Table 10: BC variables as mean, median, standard deviation and the corresponding 95% CI of the 9th grade

9th grade							
	Boys (n=15)			Girls (n=21)			
	Mean±SD (median)	95% CI		Mean±SD (median)	95% CI		U (ρ-value)*
		Lower Bound	Upper Bound		Lower Bound	Upper Bound	
BMI (kg/m²)	19,97±2,49(19,78)	18,59	21,35	20,47±2,83(19,61)	19,18	21,75	146,00(0,71)
SAD (cm)	18,23±1,81(18,10)	17,23	19,24	17,90±2,12(17,30)	16,94	18,86	127,00(0,33)
FM (%)	14,41±5,93(13,86)	11,12	17,70	19,49±3,63(18,83)	17,84	21,15	71,00**(0,01)**
WHR	0,81±0,05(0,81)	0,78	0,83	0,73±0,04(0,74)	0,71	0,74	32,00**(<0,01)**

*** Mann-Whitney test performed**
Abbreviations: BC – Body Composition; BMI – Body Mass Index; SAD – Sagittal Abdominal Diameter; FM – Fat Mass; WHR – Waist-to-Hip Ratio; SD – Standard Deviation; CI – Confidence Interval

Girls from all grade levels showed higher average BMI values than boys, although gender differences only revealed statistical significance in the 7th grade (19,20 kg/m² vs 20,41 kg/m², p=0,04) (table 8). Similar results were obtained in FM, with statistical significance at all grade levels (17,04% vs 19,35%; 14,94% vs 20,39%; 14,41% vs 19,49%, ρ=0,01) (tables 8,9,10).

The average SAD values were higher in girls than boys for the 7th and 8th grades (tables 8,9) and lower for 9th grade girls (table 10).

Average WHR values were higher in boys than girls with statistical significant at all grade levels (0,82 vs 0,78; 0,81 vs 0,73; 0,81 vs 0,73, ρ<0,01) (tables 8,9,10).

4.3. PA variables characterization (per questionnaire)

The questionnaire's PA variables descriptive data will be summarized next, stratified by gender and grade level.

Table 11: PA variables (questionnaire data) as mean, median, SD and the corresponding 95% CI of the 7th grade

7th grade							
DEE (kj/day)	Boys (n=42)			Girls (n=31)			t (ρ-value)
	Mean±SD (median)	95% CI		Mean±SD (median)	95% CI		
		Lower Bound	Upper Bound		Lower Bound	Upper Bound	
Sleep	455,14±41,56(459,00)	442,19	468,09	452,90±53,42(432,00)	433,31	472,50	656,50(0,72)*
Toilet	68,57±23,22(60,00)	61,33	75,81	94,84±32,95(90,00)	82,75	106,93	331,00**(<0,001)***
Meals	107,14±26,67(112,50)	98,83	115,45	113,95±26,58(112,50)	104,20	123,70	588,50(0,27)*
Others	48,02±93,19(0,00)	22,10	73,94	25,81±40,63(0,00)	10,91	40,71	617,50(0,40)*
Off school	366,50±211,23(338,95)	300,68	432,32	240,07±150,08(228,99)	185,02	295,12	2,79**(0,01)**
Religious	3,76±5,33(0,00)	2,10	5,43	8,53±12,69(0,00)	3,87	13,18	596,50(0,27)*
Competition	163,83±191,55(100,01)	104,14	223,52	47,84±120,12(0,00)	3,78	91,90	420,50**(<0,001)***
Domestic	60,58±94,21(21,43)	31,22	89,94	71,41±78,84(39,43)	42,49	100,32	635,00(0,56)*
Vacation	196,12±119,03(183,66)	159,03	233,21	168,25±110,37(166,68)	127,77	208,74	1,08(0,28)
Transport	35,25±20,84(33,56)	28,75	41,74	41,72±27,59(33,56)	31,60	51,84	591,00(0,50)*
Classroom	268,95±23,52(261,49)	261,62	276,28	273,27±27,77(271,85)	263,08	283,46	603,00(0,36)*
Additional	19,11±43,50(0,00)	5,55	32,66	18,32±36,38(0,00)	4,97	31,66	645,00(0,58)*
Total	1870,65±479,72(1824,61)	1721,15	2020,14	1634,58±319,59(1593,75)	1517,35	1751,80	2,55**(0,01)**

*** Mann-Whitney test performed**
Abbreviations: DEE - Daily Energy Expenditure; SD – standard deviation; CI – confidence interval

Table 12: PA variables (questionnaire data) as mean, median, SD and the corresponding 95% CI of the 8th grade

8th grade							
DEE (kj/day)	Boys (n=28)			Girls (n=24)			t (ρ-value)
	Mean±SD (median)	95% CI		Mean±SD (median)	95% CI		
		Lower Bound	Upper Bound		Lower Bound	Upper Bound	
Sleep	445,50±40,58(432,00)	429,76	461,24	450,00±44,09(432,00)	431,38	468,62	359,50(0,95)*
Toilet	73,93±29,98(60,00)	62,30	85,55	92,50±24,89(90,00)	81,99	103,01	204,50**(<0,001)***
Meals	124,55±29,04(123,75)	113,29	135,81	103,13±23,85(112,50)	93,06	113,19	220,50**(0,01)***
Others	19,63±38,06(0,00)	4,87	34,39	8,63±20,36(0,00)	0,03	17,23	316,50(0,27)*
Off school	384,69±204,26(350,96)	305,48	463,89	284,54±182,49(257,75)	207,48	361,60	254,00(0,06)*
Religious	2,16±4,63(0,00)	0,37	3,96	6,49±11,90(0,00)	1,47	11,52	306,00(0,20)*
Competition	194,56±176,89(199,16)	125,97	263,15	38,15±150,20(0,00)	-25,27	101,57	170,00**(<0,001)***
Domestic	87,57±95,11(52,82)	50,69	124,45	212,26±268,59(123,64)	98,84	325,68	216,00**(0,01)***
Vacation	237,21±109,11(224,00)	194,90	279,52	175,53±108,93(133,75)	129,54	221,53	231,00**(0,02)***
Transport	44,43±27,94(37,76)	33,60	55,27	52,29±28,04(43,75)	40,45	64,13	276,00(0,27)*
Classroom	267,23±23,52(264,08)	258,10	276,35	277,67±32,31(269,26)	264,03	291,32	-1,24(0,22)
Additional	22,36±48,00(0,00)	3,74	40,97	28,91±52,73(0,00)	6,65	51,18	360,00(0,96)*
Total	1981,49±438,90(2013,18)	1811,30	2151,67	1807,78±493,31(1647,54)	1599,47	2016,08	257,00(0,07)*

*** Mann-Whitney test performed**
Abbreviations: DEE - Daily Energy Expenditure; SD – standard deviation; CI – confidence interval

Table 13: PA variables (questionnaire data) as mean, median, SD and the corresponding 95% CI of the 9th grade

DEE (kj/day)	9th grade						
	Boys (n=25)			Girls (n=26)			U (ρ-value)*
	Mean±SD (median)	95% CI		Mean±SD (median)	95% CI		
		Lower Bound	Upper Bound		Lower Bound	Upper Bound	
Sleep	429,84±39,68(432,00)	413,46	446,22	419,54±41,29(432,00)	402,86	436,22	278,50(0,35)
Toilet	70,80±19,13(60,00)	62,90	78,70	99,23±26,52(90,00)	88,52	109,94	128,50**(<0,001)**
Meals	105,30±38,82(112,50)	89,28	121,32	100,38±28,62(112,50)	88,82	111,95	316,50(0,86)
Others	29,98±44,85(0,00)	11,46	48,49	2,78±6,86(0,00)	0,01	5,55	223,00**(0,02)**
Off school	398,26±179,99(366,49)	323,96	472,56	300,64±142,67(288,46)	243,02	358,27	231,50(0,08)
Religious	1,27±3,73(0,00)	-0,27	2,81	5,85±9,11(0,00)	2,17	9,53	242,00**(0,04)**
Competition	122,39±174,52(0,00)	50,36	194,43	79,69±122,38(0,00)	30,26	129,12	284,00(0,39)
Domestic	98,21±118,12(59,57)	49,45	146,97	151,46±133,89(101,36)	97,38	205,54	238,50(0,10)
Vacation	224,49±118,26(218,96)	175,68	273,30	204,86±145,56(172,50)	146,07	263,66	261,50(0,23)
Transport	39,51±22,29(35,96)	30,30	48,71	39,88±22,44(33,56)	30,81	48,94	324,00(0,98)
Classroom	255,59±22,65(248,55)	246,24	264,94	273,54±28,57(271,85)	262,00	285,08	195,00**(0,01)**
Additional	9,99±28,30(0,00)	-1,70	21,67	27,28±37,68(16,11)	12,07	42,50	194,50**(<0,001)**
Total	1886,08±403,59(1761,55)	1719,49	2052,67	1806,71±396,49(1785,49)	1646,56	1966,85	287,00(0,47)

*** Mann-Whitney test performed**
Abbreviations: DEE - Daily Energy Expenditure; SD – standard deviation; CI – confidence interval

Daily activities comprise the first three categories of the PA questionnaire: sleep, toilet routines and meals. Sleep category presented higher average values in boys of the 7th and 9th grades (tables 11,13) and in 8th grade girls (table 12). The toilet routines (including making up the bed), presented average values significantly higher in girls at all grade levels (68,57 kj/day vs 94,84 kj/day; 73,93 kj/day vs 92,50 kj/day; 70,80 kj/day vs 99,23 kj/day, ρ<0,01) (tables 11,12,13). Main meals average values were higher average values in girls of the 7th grade and boys of the 8th and 9th grades, with statistical significance between genders only for the 8th grade (124,55 kj/day vs 103, 13 kj/day, ρ=0,01) (table 12).

For activities performed in school, the others category covers off schedule activities, but within the school environment. The average values were higher in boys at all grade levels, with statistical significance only for 9th grade (29,98 kj/day vs 2,78 kj/day, ρ=0,02) (table 13). It should be emphasized that boys have reported spending some of their free time playing football or basketball in school while girls stated spending some of their free time listening to music, fact that may explain the difference between genders in the mentioned category.

For activities performed during the school period, the average values for off-school activities were higher in boys than girls at all the grade levels, with statistical significance in the 7th grade (366,50 kj/day vs 240,07 kj/day, ρ=0,01) (table 11).

Average values for religious activities were lower in boys than girls at all the grade levels, with statistical significance in the 9th grade (1,27 kj/day vs 5,85 kj/day, ρ=0,04) (table 13). The sports competition category showed higher results in boys than girls, at all grade levels, with statistical significance in 7th (163,83 kj/day vs 47,84 kj/day, ρ<0,01) and 8th grades (194,56 kj/day vs 38,15 kj/day, ρ<0,01) (tables 11,12). Average values for domestic activities were lower in boys than girls across all grade levels, presenting statistical significance in the 8th grade only (87,57 kj/day vs 212,26 kj/day, ρ=0,01) (table 12).

For activities performed during the vacation period, the average values were higher in boys than girls, revelling statistical significance for the 8th grade only (237,21 kj/day vs 175,53 kj/day, ρ=0,02) (table 12).

The transport category describes used means of transport, including the time spent in the home-school commute. The average values were lower in boys than girls at all grade levels, although with no statistical significance.

Classroom activities comprise school schedule (without physical education classes) and time spent doing the homework. Recorded average values for this category were lower in boys than girls at all grade levels, whereas statistical significance occurred for the 9th grade students only (255,59 kj/day vs 273,54 kj/day, ρ=0,01) (table 13). Physical education classes presented a DEE constant value (77,67 kj/day), even though 23 adolescents obtained an higher value (129,45 kj/day) (data not shown), considering they were involved in another physical exercise and health investigation project. Thus, a descriptive analysis was needless.

In additional activities (scouting, musical instrument and study center) the average values were higher in boys of the 7th grade and in girls of the 8th and 9th grades. However the difference between genders presented statistical significance for the 9th grade only (9,99 kj/day vs 27,28 kj/day, ρ<0,01) (table 13).

The total DEE calculated from the questionnaire presented higher average values in boys than girls at all grade levels, whereas the 7th grade only registered statistical significance (1870,65 kj/day vs 1634,58 kj/day, ρ=0,01) (table 11).

4.4. PA variables characterization (per accelerometry)

The accelerometry variables descriptive data will be summarized next, stratified by gender and grade level.

Table 14: PA variables (accelerometry data) as mean, median, SD and the corresponding 95% CI of the 7th grade

7th grade							
Time per day (minutes)	Boys (n=29)			Girls (n=15)			t (ρ-value)
	Mean±SD (median)	95% CI		Mean±SD (median)	95% CI		
		Lower Bound	Upper Bound		Lower Bound	Upper Bound	
Sedentary	564,20±61,29(563,54)	540,88	587,51	601,82±60,68(602,85)	568,21	635,42	-1,94(0,06)
Active	267,35±46,26(262,92)	249,76	284,95	240,48±46,57(249,50)	214,68	266,27	1,82(0,08)
LPA	210,67±44,00(211,08)	193,93	227,41	208,20±39,90(213,80)	186,12	230,30	0,18(0,86)
MPA	47,61±16,82(47,04)	41,21	54,01	28,45±8,26(28,80)	23,87	33,02	4,14**(<0,001)**
VPA	8,41±6,97(6,93)	5,76	11,06	3,41±2,57(2,68)	1,98	4,83	94,00**(<0,001)***
VVPA	0,66±0,73(0,46)	0,38	0,94	0,42±0,63(0,18)	0,07	0,77	168,50(0,23)*
TVPA	9,08±7,29(7,29)	6,30	11,85	3,83±3,09(2,86)	2,12	5,54	101,50**(<0,001)***
MVPA	56,68±22,92(54,67)	47,96	65,40	32,27±10,41(30,40)	26,51	38,04	4,85**(<0,001)**

*** Mann-Whitney test performed**
Abbreviations: LPA – Light Physical Activity; MPA – Moderate Physical Activity; VPA – Vigorous Physical Activity; VVPA – Very Vigorous Physical Activity; TVPA – Total Vigorous Physical Activity; MVPA – Moderate-to-Vigorous Physical Activity; SD - Standard Deviation; CI – Confidence Interval

Table 15: PA variables (accelerometry data) as mean, median, SD and the corresponding 95% CI of the 8th grade

8th grade							
Time per day (minutes)	Boys (n=15)			Girls (n=16)			t (ρ-value)
	Mean±SD (median)	95% CI		Mean±SD (median)	95% CI		
		Lower Bound	Upper Bound		Lower Bound	Upper Bound	
Sedentary	579,73±89,30(563,93)	530,28	629,19	623,64±71,61(629,00)	585,48	661,80	-1,52(0,14)
Active	292,00±61,61(306,72)	257,89	326,12	214,50±36,79(219,84)	194,90	234,11	4,22**(<0,001)**
LPA	236,73±44,39(240,79)	212,14	261,31	180,80±28,19(181,81)	165,78	195,82	37,00**(<0,001)***
MPA	47,22±18,95(48,00)	36,73	57,71	30,77±11,44(31,37)	24,68	36,87	2,95**(0,01)**
VPA	7,44±6,64(6,43)	3,76	11,12	2,66±2,26(2,10)	1,45	3,86	2,72**(0,01)**
VVPA	0,62±1,54(0,13)	-0,24	1,47	0,28±0,35(0,11)	0,09	0,47	104,50(0,54)*
TVPA	8,06±7,95(6,57)	3,66	12,46	2,93±2,39(2,64)	1,66	4,21	48,00**(<0,001)***
MVPA	55,28±24,82(53,94)	41,53	69,02	33,71±12,56(34,83)	27,01	40,40	57,00**(0,01)***

*** Mann-Whitney test performed**
Abbreviations: LPA – Light Physical Activity; MPA – Moderate Physical Activity; VPA – Vigorous Physical Activity; VVPA – Very Vigorous Physical Activity; TVPA – Total Vigorous Physical Activity; MVPA – Moderate-to-Vigorous Physical Activity; SD – Standard Deviation; CI – Confidence Interval

Table 16: PA variables (accelerometry data) as mean, median, SD and the corresponding 95% CI of the 9th grade

Time per day (minutes)	9th grade						
	Boys (n=7)			Girls (n=13)			U (ρ-value)*
	Mean±SD (median)	95% CI		Mean±SD (median)	95% CI		
		Lower Bound	Upper Bound		Lower Bound	Upper Bound	
Sedentary	617,54±58,15(647,58)	563,76	671,32	640,58±70,66(640,58)	597,88	683,28	41,00(0,72)
Active	235,68±33,82(240,86)	204,40	266,96	230,35±29,40(223,82)	212,58	248,11	33,00(0,32)
LPA	197,30±38,12(209,83)	162,04	232,56	190,79±25,38(188,00)	175,46	206,13	32,00(0,29)
MPA	32,38±11,43(30,54)	21,81	42,95	37,11±14,00(34,31)	28,65	45,58	35,50(0,43)
VPA	5,73±4,60(3,50)	1,48	9,98	2,32±1,82(1,60)	1,22	3,41	21,00(0,05)
VVPA	0,26±0,27(0,14)	0,01	0,52	0,12±0,15(0,05)	0,03	0,21	31,50(0,26)
TVPA	6,00±4,83(3,68)	1,53	10,46	2,44±1,89(1,68)	1,30	3,58	22,00(0,06)
MVPA	38,38±14,55(38,36)	24,92	51,84	38,55±14,52(35,82)	30,78	48,33	43,00(0,84)

*** Mann-Whitney test performed**
Abbreviations: LPA – Light Physical Activity; MPA – Moderate Physical Activity; VPA – Vigorous Physical Activity; VVPA – Very Vigorous Physical Activity; TVPA – Total Vigorous Physical Activity; MVPA – Moderate-to-Vigorous Physical Activity; SD - Standard Deviation; CI – Confidence Interval

The analysis of sedentary and active behaviours revealed girls achieved higher average values in sedentary behaviours and boys higher average values in active behaviours. The differences between genders were statistically significant only for the 8th grade (292,00 counts/min vs 214,50 counts/min, ρ<0,01) (table 15).

Light Physical Activity (LPA) average values were higher in boys at all grade levels, with statistical significance for the 8th grade only (236,00 counts/min vs 180,80 counts/min, ρ<0,01) (table 15).

The average Moderate Physical Activity (MPA) values were higher in boys of the 7th grade, with statistical significance (47,61 counts/min vs 28,45 counts/min, ρ<0,01) (table 14). Boys from the 8th grade registered also higher average values in MPA with statistical significance (47,22 counts/min vs 30,77 counts/min, ρ=0,01) (table 15). The aforementioned intensity level presented higher average values for girls of the 9th grade, yet with no statistical significance.

For the Vigorous Physical Activity (VPA) intensity level higher average values were obtained for boys when compared to girls, with statistical significance for the 7th (8,41 counts/min vs 3,41 counts/min, ρ<0,01) and 8th grades (7,44 counts/min vs 2,66 counts/min, ρ=0,01) (tables 14,15). Very Vigorous Physical Activity (VVPA) registered average values were also higher for boys at all grade levels, however with no statistical significance. Thus, Total Vigorous Physical Activity (TVPA) average values were higher in boys than girls,

with statistical significance for the 7th and 8th grades (9,08 counts/min vs 3,83 counts/min; 8,06 counts/min vs 2,93 counts/min, ρ<0,01) (tables 14,15) inasmuch as the values registered for the VPA.

For the Moderate-to-Vigorous Physical Activity (MVPA) the average values obtained were higher of 7th and 8th grades boys in comparison to girls, although higher for girls of the 9th grade, with statistical significance for the first two grade levels mentioned (56,68 counts/min vs 32,27 counts/min, ρ<0,01; 55,28 counts/min vs 33,71 counts/min, ρ=0,01) (tables 14,15). Furthermore, neither boys nor girls from any grade level attained the minimal amount of PA per day recommended for children and adolescents (Strong et al., 2005).

4.5. Correlations

Presented below are the correlations between PA and maturity status with the body composition variables. Spearman coefficient was used as the statistical measure.

Table 17: Spearman's correlation coefficient between PA and maturity variables with BC variables in the 7th grade

	7th grade									
	Boys					Girls				
	N	BMI (kg/m^2)	SAD (cm)	FM (%)	WHR	N	BMI (kg/m^2)	SAD (cm)	FM (%)	WHR
QAPACE questionnaire (kj/day)										
Sleep	38	-0,14	-0,08	-0,08	0,20	26	-0,20	-0,32	0,07	-0,21
Toilet	38	**0,33***	**0,33***	0,23	-0,19	26	0,23	0,17	0,25	**-0,42***
Meals	38	0,06	0,01	0,20	0,02	26	0,10	0,00	0,39	-0,19
Others	38	0,30	0,30	-0,04	-0,08	26	-0,13	-0,25	0,06	0,02
Off school	38	-0,05	-0,14	-0,07	-0,05	26	-0,03	0,01	-0,22	-0,09
Religious	38	0,03	-0,03	0,04	-0,11	26	-0,25	-0,06	-0,03	0,20
Competition	38	-0,07	-0,12	-0,25	0,04	26	-0,23	-0,31	**-0,57****	0,05
Domestic	38	0,22	0,24	0,25	-0,06	26	-0,03	-0,03	0,14	0,03
Vacation	38	-0,12	-0,20	-0,02	0,16	26	0,13	-0,06	-0,09	0,00
Transport	38	-0,16	-0,22	-0,12	0,16	26	-0,01	-0,01	0,38	-0,06
Classroom	38	0,00	-0,10	0,22	0,05	26	-0,19	-0,25	0,01	-0,18
Additional	38	-0,13	-0,16	-0,02	0,23	26	0,02	-0,03	-0,01	-0,04
Total	38	-0,08	-0,17	-0,13	0,04	26	-0,12	-0,25	-0,21	-0,09
Accelerometry (min)										
Sedentary	29	0,23	0,32	-0,03	0,07	15	0,08	0,36	0,27	0,23
Active	29	**-0,44***	**-0,51****	-0,21	0,07	15	0,26	-0,16	-0,02	**-0,61***
LPA	29	**-0,38***	**-0,41***	-0,04	-0,10	15	0,23	-0,13	-0,01	**-0,58***
MPA	29	-0,16	-0,24	-0,11	**0,44***	15	0,52	0,06	0,13	-0,44
VPA	29	-0,09	-0,10	-0,27	0,21	15	0,43	0,17	0,15	-0,27
VVPA	29	-0,18	-0,35	-0,18	-0,12	15	-0,12	-0,46	-0,33	-0,26
TVPA	29	-0,07	-0,10	-0,24	0,19	15	0,40	0,08	0,13	-0,23
MVPA	29	-0,11	-0,17	-0,11	0,35	15	0,49	0,05	0,11	-0,45
Maturity status (years)										
CA	37	0,28	0,23	-0,06	-0,21	22	0,42	0,18	0,21	0,08
SA	37	**0,56****	**0,48****	0,14	**-0,48****	22	0,24	0,05	0,05	-0,36
Relative SA	37	**0,55****	**0,48****	0,28	**-0,36***	22	0,16	0,03	0,05	-0,35

*** correlation is significant if ρ<0,05**
**** correlation is significant if ρ<0,01**
Abbreviations: LPA – Light Physical Activity; MPA – Moderate Physical Activity; VPA – Vigorous Physical Activity; VVPA – Very Vigorous Physical Activity; TVPA – Total Vigorous Physical Activity; MVPA – Moderate-to-Vigorous Physical Activity; CA – Chronological Age; SA – Skeletal Age; Relative SA - Difference between SA and CA; BMI – Body Mass Index; SAD – Sagittal Abdominal Diameter; FM – Fat Mass; WHR – Waist-to-Hip Ratio

For 7th grade students, the DEE assessed per questionnaire presented a statistically significant positive correlation between the toilet routines category and the BMI and SAD for boys ($r = 0,33$, $\rho<0,05$). This category showed a statistically significant negative correlation with WHR in girls ($r = -0,42$, $\rho<0,05$). The sports competition category presented a statistically significant negative correlation with FM for girls ($r = -0,57$, $\rho<0,01$) (table 17).

Analyzing the accelerometry by sedentary and active behaviours one may observe a statistically significant negative correlation between active behaviors and the BMI ($r = -0,44$, $\rho<0,05$) and SAD ($r = -0,51$, $\rho<0,01$) for boys. This category also showed a statistically significant negative correlation with WHR for girls ($r = -0,61$, $\rho<0,05$). Therefore, active behaviors display a negative correlation with the body composition variables aforementioned.

With active behaviours split across various intensity levels, it is possible to observe statistically significant negative correlation between the LPA (Light Physical Activity) and the BMI and SAD ($r = -0,38$, $r = -0,41$, $\rho<0,05$) for boys. LPA also showed a statistically significant negative correlation with WHR for girls ($r = -0,58$, $\rho<0,05$). Thus, this intensity level is inversely correlated with these body composition variables. Finally, the MPA presented a statistically significant positive correlation with WHR in boys ($r = 0,44$, $\rho<0,05$) (table 17).

The CA indicator did not present any correlation with statistically significance for both boys and girls. In the maturity variables analysis, no statistically significant correlation was observed between the SA and Relative SA variables with body composition variables in girls.

The SA indicator showed statistically significant correlation with BMI, SAD and WHR in boys ($r = 0,56$, $r = 0,48$, $r = -0,48$, $\rho<0,01$). The Relative SA indicator also showed statistically significant correlation with the BMI and SAD ($r = 0,55$, $r = 0,48$, $\rho<0,01$), and WHR ($r = -0,36$, $\rho<0,05$) in boys (table 17). These correlations were positive with the BMI and SAD variables and negative with the WHR indicator. The BMI indicator presented the highest value.

Table 18: Spearman's correlation coefficient between PA and maturity variables with BC variables in the 8th grade

	8th grade									
	Boys					Girls				
	N	BMI (kg/m²)	SAD (cm)	FM (%)	WHR	N	BMI (kg/m²)	SAD (cm)	FM (%)	WHR
QAPACE questionnaire (kj/day)										
Sleep	20	-0,44	**-0,59****	-0,35	-0,05	17	0,16	0,26	-0,12	0,42
Toilet	20	0,01	-0,08	0,19	-0,27	17	**0,48***	**0,55***	0,36	-0,01
Meals	20	-0,17	-0,21	0,04	-0,07	17	0,20	0,18	-0,10	**0,73***
Others	20	-0,22	-0,31	-0,15	-0,19	17	0,20	0,40	-0,03	0,00
Off school	20	0,30	0,25	-0,13	-0,23	17	-0,21	-0,27	-0,25	-0,04
Religious	20	-0,17	-0,07	0,08	-0,15	17	0,30	0,47	-0,01	0,42
Competition	20	0,12	0,09	-0,04	-0,27	17	-0,26	-0,31	-0,36	0,10
Domestic	20	0,21	0,16	-0,37	0,01	17	0,24	0,31	0,04	-0,07
Vacation	20	0,11	0,12	-0,04	-0,28	16	-0,14	-0,35	-0,14	0,23
Transport	19	-0,42	**-0,49***	-0,11	-0,43	17	**0,51***	**0,60***	0,30	-0,12
Classroom	20	-0,11	-0,19	0,06	-0,42	17	-0,35	-0,14	**-0,63***	0,17
Additional	20	0,08	0,23	-0,14	**0,55***	17	0,11	0,10	-0,06	0,36
Total	20	0,15	0,10	-0,19	-0,42	17	-0,09	0,01	-0,39	0,28
Accelerometry (min)										
Sedentary	15	-0,18	-0,01	0,28	-0,38	13	-0,42	-0,03	-0,26	-0,40
Active	15	-0,05	-0,13	-0,52	0,16	13	0,41	0,49	-0,04	0,39
LPA	15	-0,17	-0,22	**-0,53***	0,12	13	0,34	0,25	-0,02	0,34
MPA	15	0,14	0,08	-0,33	0,02	13	0,49	0,50	0,05	0,52
VPA	15	0,32	0,19	-0,19	-0,13	13	0,00	0,33	-0,41	0,05
VVPA	15	0,35	0,46	0,15	-0,05	13	0,31	**0,57***	0,12	-0,21
TVPA	15	0,31	0,25	-0,19	-0,10	13	-0,01	0,33	-0,38	-0,07
MVPA	15	0,16	0,10	-0,32	-0,01	13	0,38	0,47	-0,07	0,41
Maturity status (years)										
CA	17	-0,09	-0,09	-0,43	-0,01	15	-0,07	0,11	0,05	-0,16
SA	17	**0,75****	**0,70****	-0,07	-0,03	15	-0,33	-0,21	-0,02	-0,33
Relative SA	17	**0,78****	**0,80****	0,11	0,08	15	-0,30	-0,24	-0,02	-0,26

*** correlation is significant if ρ<0,05**
**** correlation is significant if ρ<0,01**
Abbreviations: LPA – Light Physical Activity; MPA – Moderate Physical Activity; VPA – Vigorous Physical Activity; VVPA – Very Vigorous Physical Activity; TVPA – Total Vigorous Physical Activity; MVPA – Moderate-to-Vigorous Physical Activity; CA – Chronological Age; SA – Skeletal Age; Relative SA: Difference between SA and CA; BMI – Body Mass Index; SAD – Sagittal Abdominal Diameter; FM – Fat Mass; WHR – Waist-to-Hip Ratio

Regarding 8th grade results, in the DEE assessed per questionnaire some categories presented significant correlations: the sleep category showed a statistically significant negative correlation with the SAD indicator for boys ($r = -0,59$, $\rho<0,01$); the toilet routines category showed statistically significant positive correlations with BMI and SAD in girls ($r = 0,48$, $r = 0,55$, $\rho<0,05$); the meals category presented a positive correlation and statistically significance with WHR in girls ($r = 0,73$, $\rho<0,05$); the transport category revealed a negative correlation and statistically significance with SAD in boys ($r = -0,49$, $\rho<0,05$) and a positive correlation and statistically significance with BMI and SAD in girls ($r = 0,51$, $r = 0,60$, $\rho<0,05$); a statistically significant negative correlation was found between the classroom activities (including the homework) and FM in girls ($r = -0,63$, $\rho<0,05$); and a statistically significant positive correlation was observed between the additional activities and WHR in boys ($r = 0,55$, $\rho<0,05$) (table 18).

No statistically significant correlation was observed between the sedentary or active behaviours and the body composition variables for both genders.

A statistically significant negative correlation was found between the LPA and FM in boys ($r = -0,53$, $\rho<0,05$) while a statistically significant positive correlation was found between the VVPA and SAD in boys ($r = 0,57$, $\rho<0,05$) (table 18).

Both boys and girls did present no correlations of statistical significance between the CA indicator and body composition variables. In a maturity variables analysis, neither SA nor Relative SA presented statistically significant correlation with the body composition variables in girls (similar results were found for the 7th grade).

A statistically significant positive correlation was observed between the SA and BMI and SAD in boys ($r = 0,75$, $r = 0,70$, $\rho<0,01$). A statistically significant positive correlation was observed between Relative SA and BMI and SAD in boys ($r = 0,78$, $r = 0,80$, $r = -0,48$, $\rho<0,01$) (table 18).

Table 19: Spearman's correlation coefficient between PA and maturity variables with BC variables in the 9th grade

	9th grade									
	Boys					Girls				
	N	BMI (kg/m²)	SAD (cm)	FM (%)	WHR	N	BMI (kg/m²)	SAD (cm)	FM (%)	WHR
QAPACE questionnaire (kj/day)										
Sleep	15	-0,15	-0,19	-0,14	**-0,57***	21	-0,01	-0,01	-0,09	-0,07
Toilet	15	0,14	0,19	0,06	0,04	21	0,00	0,17	-0,03	0,33
Meals	15	0,02	0,14	-0,01	0,06	21	0,09	-0,17	0,21	0,20
Others	15	0,01	0,01	0,09	0,22	21	-0,36	-0,32	-0,16	-0,31
Off school	15	-0,04	-0,06	0,02	0,33	21	0,22	0,21	-0,04	0,05
Religious	15	-0,26	-0,29	-0,21	-0,46	21	0,07	-0,21	-0,12	**-0,50***
Competition	15	-0,03	-0,02	0,12	0,13	21	0,25	0,28	0,12	0,25
Domestic	15	0,01	0,04	-0,22	0,18	21	0,33	0,28	0,05	-0,16
Vacation	15	0,01	-0,21	-0,25	0,15	21	0,10	-0,08	0,10	0,09
Transport	15	0,64	**0,69****	0,46	0,61	21	0,08	0,23	-0,27	0,06
Classroom	15	-0,41	-0,12	0,01	0,02	21	**-0,44***	-0,36	**-0,47***	-0,14
Additional	15	-0,23	-0,09	-0,26	-0,10	21	0,19	-0,27	0,03	-0,05
Total	15	-0,11	-0,17	-0,22	0,23	21	0,33	0,15	0,08	0,09
Accelerometry (min)										
Sedentary	6	-0,43	0,09	-0,37	0,26	12	-0,20	-0,31	-0,15	-0,20
Active	6	0,60	0,31	0,31	0,09	12	0,10	0,43	0,13	0,39
LPA	6	0,37	-0,20	0,09	-0,31	12	-0,25	0,08	-0,21	0,39
MPA	6	0,26	0,60	0,20	0,43	12	0,22	0,25	0,30	-0,01
VPA	6	0,09	0,49	0,31	0,43	12	0,00	0,39	0,06	0,25
VVPA	6	0,60	0,54	0,77	0,43	12	-0,16	0,08	-0,17	-0,43
TVPA	6	0,26	0,60	0,49	0,54	12	0,06	0,42	0,08	0,22
MVPA	6	0,20	0,66	0,26	0,54	12	0,24	0,30	0,31	0,08
Maturity status (years)										
CA	9	0,29	0,33	0,26	**0,89****	13	0,19	0,24	0,11	-0,24
SA	9	-0,08	0,18	-0,33	-0,08	13	0,25	0,40	0,08	-0,40
Relative SA	9	-0,27	-0,03	-0,32	-0,58	13	0,04	0,00	0,00	-0,16

*** correlation is significant if ρ<0,05**
**** correlation is significant if ρ<0,01**
Abbreviations: LPA – Light Physical Activity; MPA – Moderate Physical Activity; VPA – Vigorous Physical Activity; VVPA – Very Vigorous Physical Activity; TVPA – Total Vigorous Physical Activity; MVPA – Moderate-to-Vigorous Physical Activity; CA – Chronological Age; SA – Skeletal Age; Relative SA: Difference between SA and CA; BMI – Body Mass Index; SAD – Sagittal Abdominal Diameter; FM – Fat Mass; WHR – Waist-to-Hip Ratio

For the 9th grade students, the sleep category showed statistically significant negative correlation with the WHR indicator for boys (r = -0,57, ρ<0,05); religious activities revealed statistically significant negative correlation with WHR for girls (r = -0,50, ρ<0,05); transport category showed positive correlation and statistically significant with SAD in boys (r = 0,69, ρ<0,01); and classroom activities (including homework) showed statistically significant negative correlation with BMI and FM in girls (r = -0,44, r = -0,47, ρ<0,05) (table 19).

No statistically significant correlation was observed between the accelerometry variables and the body composition variables in boys and girls of the 9th grade (table 19).

The CA showed a positive correlation and statistically significant with WHR in boys (r = 0,89, ρ<0,01). Neither SA nor Relative SA presented statistically significant correlation with the body composition variables in boys.

Girls from the 9th grade did not present any statistical significance in the correlations between maturity variables and body composition variables (table 19).

4.6. Multifactorial linear regression

Presented next are the four multifactorial linear regression models created for each dependent variable, (i.e. BMI, FM, WHR, SAD), listed by gender and grade level. It is worth noting that the Relative SA indicator is presented in every model.

In the first model, the questionnaire variables are included.

The second, third and fourth models comprise the accelerometry variables. In the second model the sedentary and active behaviours are included. In the third model, sedentary behaviours, LPA, MPA and TVPA are included. In the fourth and final model, sedentary behaviours, LPA, MPA, VPA and VVPA are included.

Table 20: β coefficients from the multifactorial linear regression models between PA, maturity and BC (7th grade)

7th grade								
BMI (kg/m²)								
	Boys				**Girls**			
	Constant	**β (p)**	**95% CI**	**r²**	**Constant**	**β (p)**	**95% CI**	**r²**
Relative SA[a]	19,97	1,35(<0,001)	0,57-2,13	0,24				
Relative SA[b]	20,05	1,25(0,01)	0,37-2,14	0,22				
Relative SA[c]	20,05	1,25(0,01)	0,37-2,14	0,22				
MPA[c]					15,10	0,17(0,04)	0,01-0,33	0,24
WHR								
	Boys							
	Constant	**β (p)**	**95% CI**	**r²**				
Relative SA[a]	0,81	-0,01(0,03)	-0,02-(<-0,001)	0,13				
SAD (cm)								
	Boys							
	Constant	**β (p)**	**95% CI**	**r²**				
Relative SA[a]	17,73	0,79(0,01)	0,21-1,37	0,16				
Active[b]	22,78	-0,02(0,02)	-0,04-(<-0,001)	0,16				
Relative SA[c]	17,67	0,75(0,02)	0,13-1,37	0,16				

[a]Model 1: Assessed by questionnaire
[b]Model 2: Assessed by accelerometry (Sedentary, Active)
[c]Model 3: Assessed by accelerometry (Sedentary, LPA, MPA, TVPA)
[d]Model 4: Assessed by accelerometry (Sedentary, LPA, MPA, VPA, VVPA)
Abbreviations: Relative SA – Difference between Skeletal Age and Chronological Age; BMI – Body Mass Index; WHR – Waist-Hip Ratio; SAD – Sagittal-Abdominal Diameter; LPA – Light Physical Activity; MPA – Moderate Physical Activity; VPA – Vigorous Physical Activity; VVPA – Very Vigorous Physical Activity; TVPA – Total Vigorous Physical Activity; CI – Confidence Interval

Table 20 presented the regression models for the 7th grade. On a first model analysis one may come to a conclusion that for boys the maturity status explains 24% of the BMI's variability, 13% of the variability of WHR and 16% of the variability of SAD, i.e., the maturity status is the predictor variable. On a second model analysis it can be concluded that the boys' maturity status explains 22% of the BMI's variability and active behaviours explain 16% of the SAD's variability. In the third model it is possible to ascertain that the maturity status explains 22% of the variability of BMI and 16% of the SAD's variability. On an overall analysis it is important to note that fourth model variables were not predictive of the boys' body composition and also that none of the models identified statistically significant predictor factors for the FM in 7th grade boys.

For girls only the third model was a body composition predictor. Thus, it was verified that the MPA explains 24% of the BMI's variability and that none of the linear regression

models performed identified statistically significant predictor factors for the FM, SAD and WHR. I would like to emphasize that the maturity status was not a predictive factor of the body composition in girls, as it occurred in boys at the same grade level.

Table 21: β coefficients from the multifactorial linear regression models between PA, maturity and BC (8th grade)

8th grade								
BMI (kg/m²)								
	Boys				**Girls**			
	Constant	**β (p)**	**95% CI**	**r²**	**Constant**	**β (p)**	**95% CI**	**r²**
Relative SA[a]	19,67	1,11(<0,001)	0,51-1,71	0,48				
Sedentary[b]					41,23	-0,03(0,04)	-0,07-(< -0,001)	0,28
Relative SA[b]	19,97	1,31(<0,001)	0,54-2,08	0,52				
MPA					36,99	0,18(<0,001)	0,07-0,28	0,70
Sedentary[c]						-0,03(0,01)	-0,06-(-0,01)	
Relative SA[c]	19,97	1,31(<0,001)	0,54-2,08	0,52				
Relative SA	19,54	1,35(<0,001)	0,69-2,00	0,66				
VVPA[d]		0,70(0,04)	0,03-1,36					
SAD (cm)								
	Boys				**Girls**			
	Constant	**β (p)**	**95% CI**	**r²**	**Constant**	**β (p)**	**95% CI**	**r²**
Relative SA[a]	17,65	0,76(<0,001)	0,41-1,12	0,56				
Relative SA[b]	17,89	0,89(<0,001)	0,43-1,36	0,59				
MPA[c]					14,30	0,12(0,03)	0,01-0,22	0,31
Relative SA[c]	17,89	0,89(<0,001)	0,43-1,36	0,59				
Relative SA	17,63	0,92(<0,001)	0,52-1,31	0,70				
VVPA[d]		0,42(0,04)	0,01-0,82					
FM (%)								
	Boys							
	Constant	**β (p)**	**95% CI**	**r²**				
LPA[c]	42,31	-0,11(0,02)	-0,19-(-0,02)	0,34				

[a]Model 1: Assessed by questionnaire
[b]Model 2: Assessed by accelerometry (Sedentary, Active)
[c]Model 3: Assessed by accelerometry (Sedentary, LPA, MPA, TVPA)
[d]Model 4: Assessed by accelerometry (Sedentary, LPA, MPA, VPA, VVPA)
Abbreviations: Relative SA – Difference between Skeletal Age and Chronological Age; BMI – Body Mass Index; SAD – Sagittal-Abdominal Diameter; FM – Fat Mass; LPA – Light Physical Activity; MPA – Moderate Physical Activity; VPA – Vigorous Physical Activity; VVPA – Very Vigorous Physical Activity; TVPA – Total Vigorous Physical Activity; CI – Confidence Interval

Table 21 showed the regression models for the 8th grade. On a first model analysis one may conclude that for boys, the maturity status explains 48% of the BMI's variability and 56% of the SAD's variability. On a second model analysis it can be concluded that the boys' maturity status explains 52% of the BMI's variability and 59% of the SAD's variability. In the third model it is possible to ascertain that the maturity status explains 52% of the variability of BMI and 59% of the variability of SAD. This model also explains 34% of the variability of the FM through the LPA. From the fourth model it can be concluded that the maturity status along with the VVPA explains 66% of the variability of the BMI and 70% of the variability of the SAD.

Regarding regression models for 8th grade girls the analysis of the second model revealed that the sedentary behaviours account for 28% of the BMI's variability. In the third model the MPA along with sedentary behaviours explains 70% of the BMI's variability and that the MPA alone explains 31% of the SAD's variability.

It should be pointed out that the first and fourth models were not predictive of the body composition in girls from the 8th grade and also that none of the models identified statistically significant predictor factors for the FM and WHR.

The analysis of the 9th grade sample is not presented here as no predictive factors were identified for the body composition in both genders.

CHAPTER 5. DISCUSSION

5.1. Discussion of results

The purpose of this thesis was to examine the associations of PA in Portuguese adolescents' body composition of both genders, taking into account the maturity status as a co-variable. In order to accomplish this task and as a starting point, the differences in body composition, maturity status and PA variables from both genders will be discussed, followed by an understanding of the possible associations between PA and maturity status on the body composition variables.

Based on Cole's BMI cut-off points for overweight and obesity (2000) it is possible to conclude that the adolescents in this study sample were not at risk as the BMI values obtained are lower (19,20 kg/m^2 vs 20,41 kg/m^2, 7th grade; 18,55 kg/m^2 vs 20,03 kg/m^2, 8th grade; 19,97 kg/m^2 vs 20,47 kg/m^2, 9th grade, for boys and girls, respectively) than Cole cut-off points for overweight, taking into account the chronological mean age (21,56 kg/m^2 vs 22,14 kg/m^2, 7th grade; 22,27 kg/m^2 vs 22,98 kg/m^2, 8th grade; 22,96 kg/m^2 vs 23,56 kg/m^2, 9th grade, for boys and girls, respectively). The BMI results for girls were higher than in boys at all grade levels, this being congruent with the results obtained from Sardinha et al. (2010), although with statistical significance only for the 7th grade.

The FM was significantly higher in girls when compared to boys at all grade levels (17,04% vs 19,35%, 7th grade; 14,94% vs 20,39%, 8th grade; 14,41% vs 19,49%, 9th grade, for boys and girls respectively), however these results did not represent risk of obesity according to Williams et al. (1992). Furthermore, one may assume the higher BMI in girls is due to the FM, just as Vink et al. (2010) observed puberty is of influence on FM in girls.

In contrast, the WHR was significantly higher in boys from all grade levels. A possible cause of such findings may be due to the fact that the waist circumference in girls tends to diminish as well as the hip circumference tends to increase with age leading to a lower WHR. One shouldn't disregard the fact that differences in the skeletal structure may confound the results (Ley et al., 1992 as cited in Taylor et al., 2000), as robustness is further developed in prepubertal boys when compared to girls of the same age (Jürimäe & Jürimäe, 2000).

The SAD is considered a reliable indicator of visceral obesity among children and adolescents (Al-Daghri et al., 2010), however for this study there were no significant differences between genders. A closer look allows for a better understanding of these discrepancies, as the method used to determine the maturity status for Al- Daghri et al. (2010) was the secondary sex characteristics and in the present study the chosen method was the skeletal age.

Considering the differences between genders in total DEE (assessed per questionnaire) and active behaviours (assessed per accelerometry), boys reached higher amounts of PA than girls (however only the 7th grade reveals statistical significance for total PA as well as the 8th grade for active behaviours), which is in agreement with several authors (Mechelen et al., 2000; Trost et al., 2002; Ekelund et al., 2004b; Riddoch et al., 2004; Barbosa et al., 2007; Sherar et al., 2007; Seabra et al., 2008), thus one may affirm the QAPACE questionnaire (Barbosa et al., 2007) apparently reflects the results of accelerometry in the total DEE of adolescents aged 12 to 16, probably as this questionnaire includes all of the available PA patterns and is composed by specific closed questions, what is crucial given the range of ages as shown by Freedson et al. (1998). Furthermore, the girls spent more time in sedentary activities than boys across the grade levels, which is congruent with some authors (Ekelund et al., 2004a; Rodrigues et al., 2010), however without statistical significance.

On the analysis of the differences in PA across grade levels it is possible to conclude that the total DEE increases with age for both genders between 7th and 8th grade students, which in congruent with Seabra et al. (2008), however between 8th and 9th grade students the DEE decreases, which is congruent with the aforementioned authors. Through accelerometry assessment the sedentary behaviours increase for both genders across grade levels and active behaviours increased in boys and decreased in girls between the 7th and 8th grades, although opposite results were obtained between 8th and 9th grade students. A noteworthy fact is that 9th grade sample was of small extension and also encompassed sports competition girls.

Regarding the activities described in the questionnaire, time spent in sleep was higher in boys of the 7th and 9th grades as was in girls of the 8th grade. Although these not being significantly statistical differences it is relevant to emphasize that adolescents that sleep longer spend more time in PA of all intensities, however these associations disappear when adjusted for age and maturity status (Ortega et al., 2011). Concerning the toilet routines category, girls spend more time in these activities than boys with statistical

significance across all grade levels. This can be explained with the typical concern for appearance in the adolescent girls.

The activities included in others category (performed in school, yet outside of schedule), off school activities, vacation activities and competition activities were higher in boys than girls across all grade levels. Despite the differences in others category being devoid of statistical significance and considering the time spent in physical education classes being the same for both genders, boys often reported to take part in activities such as soccer or basketball while girls opt for walking, listening to music or talking. On the other hand the off school activities have statistical significant differences for the 7th grade, the vacation category for the 8th grade and the competition activities for 7th and 8th grades. The 9th grade students did not present statistical significant differences probably due to the fact that more girls from this grade level take part in competition sports, leading to an increase in average values and closing the gap between genders. An overall analysis of the mentioned activities revealed a lower participation of girls in physical activities, mainly in of non-organized forms (others, off school and vacation activities) which may be a cause for concern, given the fact that girls would benefit from bone accrual case they took part in leisure PA from prepuberty to early adulthood (Völgyi et al., 2010).

Concerning religious, domestic and classroom activities girls registered higher average values than boys across all grade levels, with statistical significance in the 9th grade for religious and classroom activities and in the 8th grade for domestic activities. Higher levels in domestic activities were also registered by Fragoso et al. (2009), probably due to psychosocial factors (Rodrigues et al., 2010). As a side note on this matter it should be mentioned that domestic activity values were higher in adolescent girls as this kind of society instilled behaviour is expected from them at this point in time.

Relating to the PA intensity levels assessed by accelerometry and differences between genders, 7th and 8th grade boys spend more time performing physical activities of all intensity levels than girls, with statistical significant differences for LPA in the 8th grade. These findings are in contrast with Fragoso et al. (2009), who reported higher amounts of low intensity PA in girls, however the collection method from these authors was solely a questionnaire. Statistical significance was also observed in MPA, VPA and MVPA for the 7th and 8th grades, favouring the boys, which is congruent with Fragoso et al. (2009). In other words boys engage more frequently in physical activities of higher intensity as as shown by Rodrigues et al. (2010), however this is not supported by Riddoch et al. (2004). Considering the VPA, some authors had similar results (Trost et al., 2002; Sherar et al.,

2007), however Mechelen et al., (2000) did not find any gender differences at this intensity level. Furthermore, Trost et al. (2002) also stated that for both genders the time spent in MVPA and VPA had an inverse relationship with the grade level. In fact, boys obtained similar results in this study, while for girls the VPA, VVPA and TVPA decreased and the MPA and the MVPA increased across all grade levels, which contrasts with the results from the aforementioned author.

According to Sherar et al. (2007), the changes that occur in the adolescence are gradual and vary among individuals, however it is widely accepted that girls mature earlier than boys, which is consistent with the results obtained in the present findings. Moreover Sherar et al. (2007) supports the idea the gender differences in maturity status may be the reason why research consistently shows that girls are less active than boys of the same CA. As a matter of fact, in the present study boys showed lower maturity status at all grade levels than girls, with statistical significance in the 8th grade only. Regarding the PA results, boys were more active than girls at all grade levels, as they show a consistently higher amount of PA at all intensity level and lower participation in sedentary behaviours (9th grade girls presented slight improvements in MVPA, yet devoid of statistical significance). Emphasis must also be placed on the fact that between the 7th and 8th grades the amounts of MPA, VPA, TVPA and MVPA remain significantly higher in boys and that active behaviours and LPA were significantly higher in 8th grade boys. This may be due to the delayed maturity status in boys.

Analysing the associations of PA along with the maturity status on body composition it is possible to affirm that maturity status is the variable that consistently to the variability of BMI for the 7th grade boys, ranging between 22% and 24%, with positive relations. Thus, if the maturity status increases the BMI value also increases. On the other hand, for 7th grade girls, 24% of BMI's variability is explained by MPA with positive relations. Inasmuch as Baxter-Jones et al. (2008) found that, an increase in PA also increases the fat-free mass (controlling for maturity status), this could be a possible explanation for the BMI's variability in 7th grade girls. The maturity status also explained 13% of WHR's variability in the 7th grade boys with negative relations, i.e., if maturity status increases the WHR value decreases, which is to be expected, given the fact that the maturation process comprises a growth spurt (Vieira & Fragoso, 2006) and consequently a lower WHR. The maturity status accounts as well as for 16% of SAD's variability, with positive relations and the active behaviours also explains 16% of the SAD's variability, however with a negative relation. Furthermore, the LPA and active behaviours had significant negative correlations with the SAD in boys at this grade level, thus it can be hypothesized that although the

maturity status explains the increase in SAD, the active behaviours (probably due to LPA) lead to a decrease in SAD. Regarding the predictive factors for the FM, neither PA nor maturity status explain the variability of this body composition indicator. Considering bone development is driven by muscle development, in part due to PA (Baxter-Jones et al., 2008), one may raise the following issue: if girls and boys had higher amounts of PA will this influence the FM? This issue needs a further investigation.

Besides the obtained results for the 7th grade, the differences in maturity status were only significant for the 8th grade, where boys showed a delay and girls an advance in maturity status. Therefore, such as the results obtained for the 7th grade, the associations of PA along with maturity status on the body composition of the 8th grade boys were consistently and positively explained through maturity status. Actually the maturity status contributes to a larger variability of the BMI, i.e., the maturity status explains 48% of the BMI's variability in the questionnaire included model; 52% in the second and third models which include the accelerometry; yet, accounting for 66%, the fourth is the best explanatory model. In this fourth model the BMI's variability was explained through VVPA along with maturity status, with positive relations. On the other hand, for 8th grade girls the maturity status was not a predictive factor of BMI, rather the sedentary behaviours explain 28% of BMI's variability, these behaviours along with the MPA explain 70% of the BMI's variability. Therefore, the relations of the aforementioned indicator were positive with MPA and negative with sedentary behaviours, i.e., the BMI increases with increased MPA and decreases with sedentary behaviours, which was not to be expected. On a Spearman's coefficient analysis the sedentary behaviours and MPA were not significantly correlated with the BMI in 8th grade girls.

Moreover, the BMI is not the best indicator of body composition as it does not present qualitative data. Thus, a deeper analysis would be required in order to ascertain whether obtained values are a consequence of fat-free mass rather than fat mass. An hypothesis may arise from this matter: obtained BMI values are due to fat-free mass, however Moliner-Urdiales et al. (2010) found no association between PA and strength tests, even whit age, maturity status and free-fat mass control. This issue requires further investigation.

Analysing the remaining variables of the body composition for the 8th grade boys, 56% to 70% of the SAD's variability was explained by the maturity status, the fourth being the best explanatory model. For 8th grade girls the only predictive factor for SAD was the MPA

(31%), with positive relations, however the Sperman's coefficients were not significant between MPA and SAD.

For 8th grade girls neither PA nor maturity status explain the results obtained in the remaining variables of body composition (WHR and FM). The fact that maturity status was not a predictive factor for the body composition indicators in girls at this grade level, is noteworthy. Furthermore, PA and maturity status were also not predictive factors of WHR in 8th grade boys, however LPA predicted 34% of the FM's variability in boys, with negative relations.

No predictive factors were identified for the body composition variables in both genders at the 9th grade, this may be due to the reduced sample extent.

5.2. Study Limitations

The most positive aspects to retain are:

- The assessment of PA by accelerometry, as these devices have multiple advantages over other objective methods (Corder et al., 2008);
- The specific closed question questionnaire comprising all of the PA patterns (Freedson et al., 1998), namely competition sports, domestic activities and vacation activities;
- The SA's assessment as this is the best maturational index in accordance with several authors (Beunen et al., 1997; Mirwald et al., 2002; Sherar et al., 2004; Malina et al., 2004) and also the hand-wrist X-ray as this is the best method to assess the maturity status (Jürimäe & Jürimäe, 2000; Malina et al., 2004).

Nevertheless, the results can be influenced by certain aspects that must be taken into account as study limitations:

- The sample was diminished for the 9th grade when compared to the 7th and 8th grades, which produced a low recruitment rate (valid data);
- The questionnaire data may have been influenced by the ability of the adolescents to accurately recall daily activities;

- In spite of accelerometers being an objective method of PA assessment, these might have altered the adolescents regular activity, in particular girls as accelerometers clash with their idea of style and fashion. This resulted in several gaps of data;
- The accelerometers outputs may have result in underestimation as some activities were non-monitored, (e.g. during swimming and contact sports the monitors had to be removed) and also as the exercise intensity assessment during weight-bearing activities is not accurate (e.g. cycling);
- The data was organized by grade level and gender instead of being cohort by CA, which might have lead to a loss in sensitivity.

5.3. Considerations and recommendations

Cross-sectional studies serve the purpose of understanding chosen variables in a precise moment in time and potential confounders can be controlled, although causal relation may depend on several confounders not considered and as biological maturation is a process, some factors may be misunderstood, such as sociocultural (Rodrigues et al., 2010), dietary composition or genetic variation. Thus, it is important to proceed with longitudinal investigation on this matter, namely adopting a biocultural perspective (Malina, 2008 as cited in Sherar et al., 2010).

Regarding future research it is important to ensure the accelerometers application produces as much valid data as possible, thus an incentive is highly recommended (e.g. planning an interesting outdoor activity along with the physical education teachers, to be included in the school's annual activity planning, thus subjects who'd fulfill the minimum study requirements for valid data would then be rewarded with a participation in said activity without any financial cost).

The determination of the maturity status is useful for a successful professional intervention, rendering it more accurate. In the physical education area, teachers can group their students by maturity status and assigned specific tasks for each group. In the sports competition area teams could be grouped by maturity status instead of chronological age in order to close the age gap.

However the maturity status assessment will always be dependent on financial costs. In order to reduce this limitation, health professionals may use a secondary sex characteristics questionnaire, as Völgyi et al. (2010) found the Tanner stage I to be a more sensitive period to exercise in order to provide benefits on bone development than Tanner stage III. They also found weight-bearing activities during postmenarcheal years to be important for bone health.

The assessment of PA levels of children/adolescents is also useful for teachers' intervention. Thus, if the children/adolescents do not reach the minimums of PA stated by health recommendations, physical education teachers can further develop intervention programs aiming these guidelines fulfillment.

CHAPTER 6. CONCLUSIONS

The main purpose of this study was to establish the associations of the PA in the adolescents' body composition, controlling for maturity status. Based on the obtained results and reporting to the hypotheses it is possible to conclude that:

- Maturity status is higher in girls when compared to boys across all the grade levels, with significant differences for the 8th grade, confirming the hypothesis;
- BMI and FM are higher in girls when compared to boys across all the grade levels, with significant differences in the 7th grade for the BMI and in all grade levels for the FM; the WHR is higher in boys at all grade levels, always with significant differences; therefore the hypothesis is partially confirmed since the SAD was higher in girls from the 7th and 8th grades, but not in the 9th grade;
- PA levels are higher in boys than girls irrespective of grade level, with significant differences at the 7th and 8th grades, confirming the hypothesis;
- PA levels decreased with increasing age between the 8th and 9th grades for both genders, however the hypothesis was not fully confirmed once the PA levels increased between the 7th and 8th grades in boys and in girls when assessed by questionnaire;
- The highest values of total PA are associated with the lowest levels of body composition variables for both genders, with exception of FM in girls. Thus, the hypothesis is partially confirmed.
- Boys with higher values of MVPA present the lowest levels in BMI and SAD, but not in FM and WHR; on the other hand girls with higher values of MVPA present the lowest levels in FM and WHR, however for BMI and SAD the results are inverse. Thus, the hypothesis is partially confirmed.
- The adolescents who present an advance in maturity status (8th grade girls) also have higher FM and SAD values, however the hypothesis that the body composition values are higher in adolescents with an advanced maturity status is partially confirmed as BMI and WHR increased.
- The adolescents who present a delay in maturity status (8th grade boys) also present higher levels of PA (in both PA assessment methods), which does not confirm the hypothesis.

It is also possible to conclude that the maturity status is the predictive factor that consistently explains the body composition variables for 7th and 8th grade boys (with exception of FM). Furthermore, the active behaviours, the LPA, and the VVPA along with maturity status are also predictors for body composition in the boys. On the other hand, the maturity status is not a predictive factor for body composition in girls, however MPA explains BMI's variability at 7th grade girls, and sedentary behaviours and MPA explains SAD's variability at 8th grade girls.

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Appendix 1

Informed Consent

Appendix 2

Questionnaire QAPACE

(Quantification de l'Activité Chez les Enfants)

Portuguese Version