Original Article

Age and gender differences in Body Mass Index, ocular, and back disorders in 8-12-year old children

FÉLIX ZURITA ORTEGA[1] ✉, MAR CEPERO GONZÁLEZ[1], LUÍS RUIZ RODRÍGUEZ[1], DANIEL LINARES GIRELA[1], JAVIER CACHÓN ZAGALAZ[2], FÉLIX ZURITA MOLINA[1]

[1]*Department of Didactics of Corporal Expression, Faculty of Education Sciences, University of Granada, Spain*
[2]*Department of Didactics of Corporal Expression, Faculty of Education Sciences, University of Jaén, Spain*

ABSTRACT

Zurita-Ortega F, Cepero M, Ruiz L, Linares D, Cachón J, Zurita-Molina F. Age and gender differences in Body Mass Index, ocular, and back disorders in 8-12-year old children. *J. Hum. Sport Exerc.* Vol. 6, No. 4, pp. 657-672, 2011. The aim of this study was to determine levels of body mass index, spinal alterations, and ocular myopia in the Primary school population of the province of Granada (Spain) as well as any possible sex and age related variations. Two thousand nine hundred fifty-six children [1,481 boys (50.1%) and 1,475 girls (49.9%)] aged 9.61±1.21 years (8-12) from 19 schools in the province of Granada, took part in this study. The body height and body mass were measured and body mass index was calculated as general anthropometric parameters. Adams Test and Snellen's E test were used to detect spine alterations and visual acuity respectively. The results showed that 26.3% of the children were overweight or obese, 24.5% had spinal disorders (16% scoliosis and 8.5% hyperkyphosis; $p<0.002$), and 12.5% ocular disorders. Girls had higher rates of Underweight and obese than boys ($p<0.000$). Boys had higher rates of scoliosis than girls ($p<0.002$). No statistically differences were found in the use of corrective glasses between boys and girls. Children with hyperkyphosis were more obese. The results indicate the need to develop training and physical exercise programmes to prevent and treat child obesity, and spinal alterations. **Key words:** BMI, OBESITY, SCHOOL HEALTH, SPINE, SCOLIOSIS, HYPERKYPHOSIS, MYOPIA.

✉ **Corresponding author.** C/Sainz Cantero nº 1 2º Izquierda. CP 18002. Granada. Spain.
E-mail: felixzo@ugr.es
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INTRODUCTION

In modern society, sedentarism is becoming an ever more common factor in increased obesity. In this sense, writers such as Bras (2005) and Bousoño (2007) state that obesity, as a social phenomenon, is the result of an imbalance between daily calorie intake (overfeeding) and a marked fall in calorie consumption, basically due to sedentarism. In addition, it is important to point out that bad dietary habits and physical inactivity are increasingly affecting children and young people (Aranceta et al., 2005; Velásquez et al., 2003 & Wärnberg et al., 2006). Furthermore, Loizaga (2005) and Prado et al. (2007) state that BMI levels in industrialised countries are higher than in more socially deprived areas. Martinsen (2000), Gonzalez (2002), Martín et al. (2004) and Kautiainen et al. (2005) agree that child obesity is determined by sedentary habits (the use of new technologies, video games, computers, etc.) which promote little physical activity, thus affecting the overall condition of the school population. Meanwhile, Jiménez (2007) underlines the very high correlation between sedentarism and obesity.

To sum up, despite the fact that obesity as pathology may have a multifactorial etiology, the underlying cause of most cases is an imbalance between daily calorie intake and energy expenditure. The fact is that this phenomenon appears to be more marked in developed countries where hypercaloric diets (overfeeding) are combined with ever more sedentary lifestyles. The significant increase in younger members of the population in this regard deserves special attention.

It is worth highlighting the negative effect obesity has on most parts of the body's systems and structures (Krauss et al., 1998; Bellido, 2006). In this respect, many writers have indicated the relationship that exists between obesity and the musculoskeletal system (Balagué et al., 1988; Dule, 2006). Indeed, there is no doubt about the effect child obesity has on overloading the locomotor system, which leads to numerous orthopaedic disorders (Cidon, 2006) and back pains (Kumar et al., 2003 & Pernille et al., 2005).

Ocular pathology (myopia) is a risk factor in child obesity, as it can lead to retinal detachment, as shown by Miller (1999). In addition, Cordain et al. (2002), Griffiths (2003) and Quevedo et al. (2007) found a link between myopia in school age children and the more western lifestyles that induce sedentarism and child obesity.

Due to ocular alterations, specifically myopia, many writers (Cantó et al., 1998; Berrocal et al., 2001 & Romañá, 2004) have stated that poor vision at a young age causes a postural imbalance that leads to anomalous ergonomic positions that favour the appearance of scoliotic and hyperkyphotic attitudes, which affect all of the structures in a schoolchild's body. This establishes a new relationship between visual alterations, in the case of this study myopia, and back problems. In this sense, Romañá (2004) underlines the importance of the term school hygiene in preventing certain pathologies caused in the school environment, which is supported by Hahn (1988), Santonja et al., (1992) and Vílchez (2007), who mention the importance of good postural education to avoid postural imbalances that have a negative effect on the child, thus preventing what Berrocal et al. (2001) define as the "crooked child" syndrome.

The aim of this study was to determine levels of body mass index, spinal alterations, and ocular myopia in the Primary school population of the province of Granada (Spain) as well as any possible sex and age related variations.

MATERIAL AND METHODS

Participants
Two thousand nine hundred fifty-six children [1,481 boys (50.1%) and 1,475 girls (49.9 %)] aged 9.61±1.21 years (8-12) from 19 schools in the province of Granada, took part in this study. The subjects were divided into 5 chronological ages groups (Figure 1).

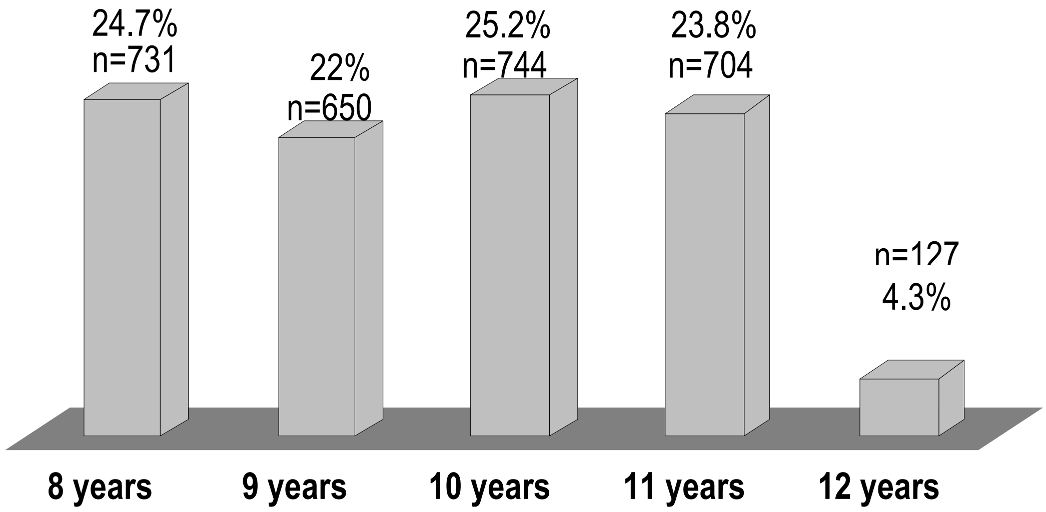

Figure 1. *Subjects by chronological age groups.*

All children and parents were thoroughly informed of the purposes and content of the study, and written informed consent was obtained from the parents and children before participation. The teachers and head teachers were informed of the purposes of the study and gave their consent to perform the experiments. This study was approved by the Ethics Committee of the University of Granada (Spain).

Procedure

Body Mass Index (BMI)

For adults, obesity is defined as a BMI greater than 30, but for children this is more relative, meaning that the WHO charts for each age and sex must be used, as stated by Seedo (1996), Serra et al. (2003) and Salas et al. (2007). BMI Percentile was used to determine category weight. Possible results were: Underweight=Less than the 5th percentile; Healthy weight=5th percentile to less than the 85th percentile; Overweight=85th to less than the 95th percentile; Obese=Equal to or greater than the 95th percentile. Before calculating BMI, obtain accurate height and weight measurements. The body height (Martin metal anthropometer) and body mass (medical electronic scale; A & D Instruments Ltd., Abingdon, UK) of the subjects were measured to the nearest 0.1 cm and 0.05 kg, respectively. Body mass index ($kg \cdot m^{-2}$) was calculated.

Adams Test

This resource was used to detect orthopaedic alterations of the spine (Reamy et al., 2001; Skaggs et al., 2006). The spine of the individual is assessed, establishing that the increase in spinal or lumbar protrusion generates an image of the hump and/or protuberance that, in the case of scoliosis, will be asymmetric if it is lateral, and central for hyperkyphosis (Zurita et al., 2008). The increase in the protrusion is regarded as positive for the test assessment.

Snellen's E test

A closed question questionnaire indicating the presence of signs of visual problems, also noting the use of corrective lenses for sight. Participants in this situation were given Snellen's E test for visual acuity (Delgado, 2006; Sorel et al., 2007). The assessment was carried out by placing the panel at a distance of 5 metres and telling the pupils to take off their lenses and tell the assessor where the letter "E" was. This test, together with the items asked, helped to ascertain those children with ocular pathology (Myopia).

In 500 subjects with characteristics similar to those in the study, Adams and Snellen's E Tests were applied to calculate the reliability of measurement. The first one hundred examinations were recorded on video and later discussed by the group, analysing those methodological aspects that could lead to differences and/or errors in the data collection process. The remainder were analysed in groups of 60 by the different assessors, in each case comparing the number of coincidences, which exceeded 90% at the end of the process. Thus, the corresponding test ($r = 0.92$) reflecting low inter examiner variability was established.

Data analysis

The analyses were conducted using the SPSS version 15.0 statistical software program (SPSS, Inc., Chicago, IL). Standard statistical methods were used to calculate mean (x) and SD. A Fisher's least significant differences test was used to determine the differences between age groups. The differences by gender in BMI and tests performed were analyzed using *t* tests. For all tests, the significance level was set at $p<0.05$.

RESULTS

In Figure 2, the BMI categories are presented. Most of the subjects had healthy weight. Only a 7.8% (n = 231) of subjects was obese.

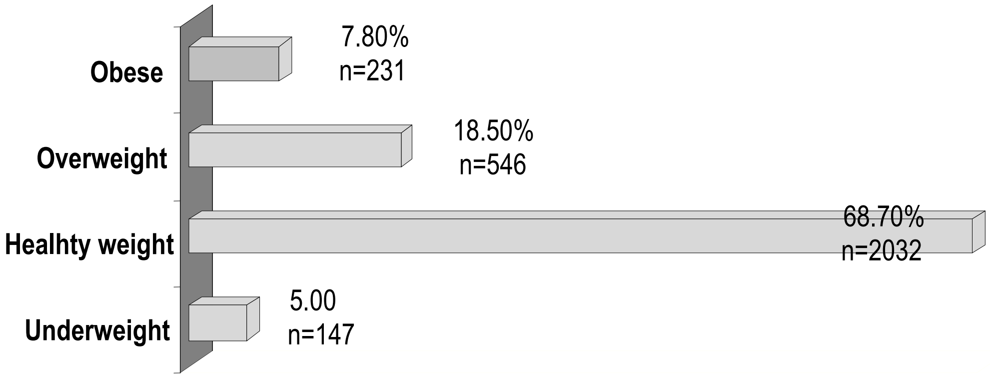

Figure 2. *Distribution of Body Mass Index categories.*

In Table 1 and 2, the frequency and percentage of spinal and ocular disorders are presented.

Table 1. *Frequency and percentage of spinal disorders.*

	Frequency	Percentage
No disorders	2233	75.5 %
Scoliosis	472	16.0 %
Hyperkyphosis	251	8.5 %
Total	2956	100.0 %

Table 2. *Frequency and percentage of subjects with or without corrective lenses.*

Lenses	Frequency	Percentage
No	2587	87.5 %
Yes	369	12.5 %
Total	2956	100.0 %

Figure 3 shows BMI categories by gender. Girls had higher rates of underweight and obese than boys (p<0.000).

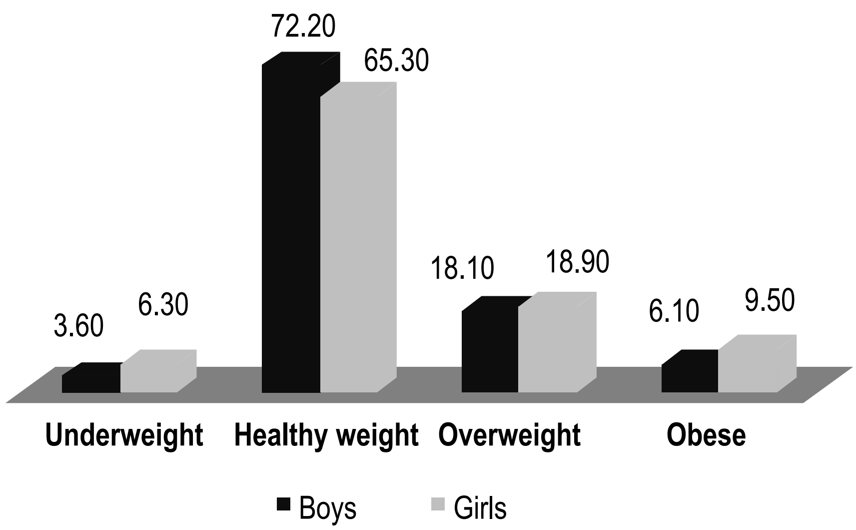

Figure 3. *BMI categories by gender.*

Statistically significant differences found between the overweight variable and age groups (*p*=0.000). The inflection produced in almost all categories at 10 years old is striking, as well as the fact that the prevalence of low weight among 8 and 9 year olds is practically double that of the 10 and 11 year olds (Table 3).

Table 3. *Distribution of BMI categories by age (p=0.000).*

BMI categories		Age (y)					Total
		8	9	10	11	12	
	N	45	42	22	26	12	147
Underweight	% BMIcat	30.6%	28.6%	15.0%	17.7%	8.2%	100.0%
	% Age	6.2%	6.5%	3.0%	3.7%	9.4%	5.0%
	N	518	455	490	486	83	2032
Healthy weight	% BMIcat	25.5%	22.4%	24.1%	23.9%	4.1%	100.0%
	% Age	70.9%	70.0%	65.9%	69.0%	65.4%	68.7%
	N	111	115	158	136	26	546
Overweight	% BMIcat	20.3%	21.1%	28.9%	24.9%	4.8%	100.0%
	% Age	15.2%	17.7%	21.2%	19.3%	20.5%	18.5%
	N	57	38	74	56	6	231
Obese	% BMIcat	24.7%	16.5%	32.0%	24.2%	2.6%	100.0%
	% Age	7.8%	5.8%	9.9%	8.0%	4.7%	7.8%
	N	731	650	744	704	127	2956
Total	% BMIcat	24.7%	22.0%	25.2%	23.8%	4.3%	100.0%
	% Age	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

BMIcat=Body mass index category.

In relation to sex, statistically significant differences were found in the number of scoliotic disorders (p=0.002). Considering the total population of subjects with scoliosis (16%), is more frequent in males (57.6%; n= 272) than in females (42.4%; n=200). It should be highlighted that the number of hyperkyphosis cases found was very similar for both sexes, as can be seen in Table 4.

Table 4. *Spinal disorders by gender (p=0.002).*

Spine		Gender		Total
		Male	**Female**	
	N	1087	1146	2233
No Disorders	% Spinal disorders	48.7%	51.3%	100.0%
	% Gender	73.4%	77.7%	75.5%
	N	272	200	472
Scoliosis	% Spinal disorders	57.6%	42.4%	100.0%
	% Gender	18.4%	13.6%	16.0%
	N	122	129	251
Hyperkyphosis	% Spinal disorders	48.6%	51.4%	100.0%
	% Gender	8.2%	8.7%	8.5%
	N	1481	1475	2956
Total	% Spinal disorders	50.1%	49.9%	100.0%
	% Gender	100.0%	100.0%	100.0%

Statistically significant differences were found (*p*=0.003) with regard to age ranges and their relationship with spinal disorders. With 12 year old pupils, only 69.3% of the subjects did not show any spinal deviation symptoms. In the same way, participants with scoliosis were distributed homogenously over the five age groups and the 11 year old hyperkyphotics showed much lower levels than the other age (5.7%), as shown in Figure 4.

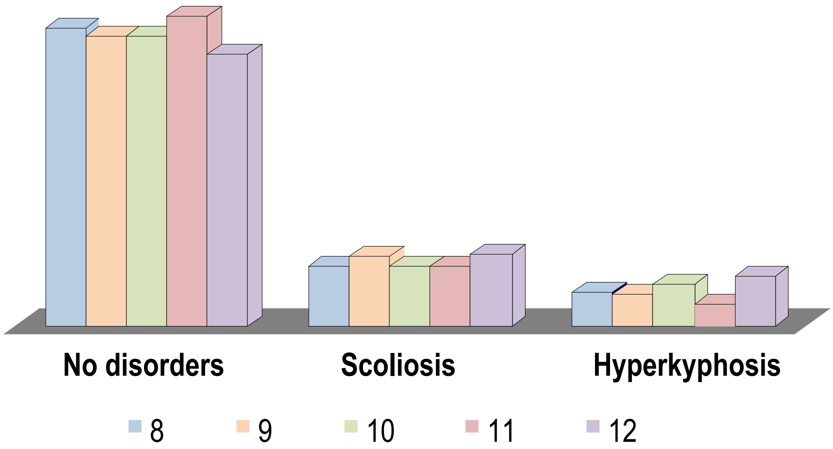

Figure 4. *Spinal disorders by age (p=0.003).*

The results show that, by gender, girls use lenses more than boys (Figure 5). However, no statistically significant differences were found (*p*=0.323).

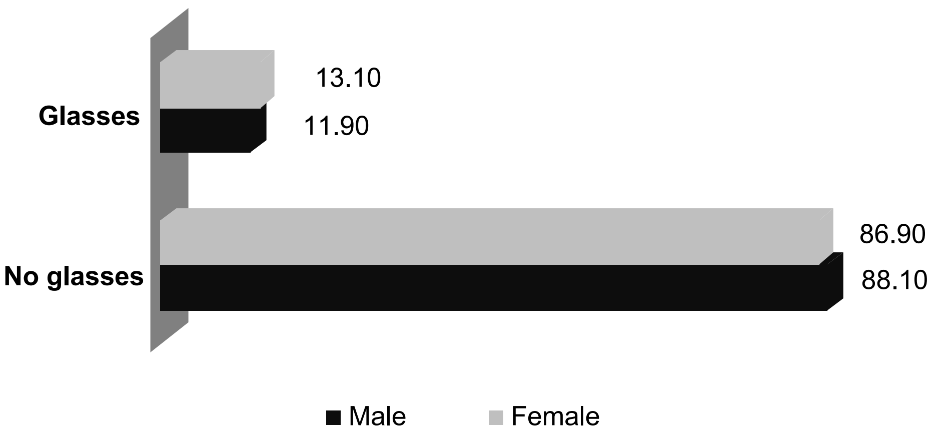

Figure 5. *Use of corrective lenses by gender in % (p=0.323).*

Highly statistically significant differences were obtained (*p*=0.000) with the distribution of the use of lenses between the different age groups. These differences are a result of the increased use of corrective lenses in the study sample as the subjects grow older. Therefore, 93.8% of 8 year old subjects did not use corrective measures, compared with 81.1% of 12 year olds (Figure 6).

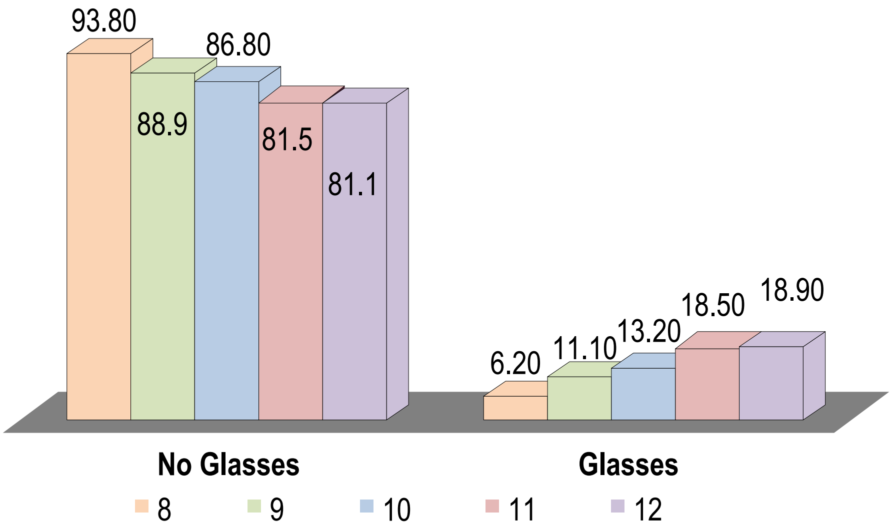

Figure 6. *Use of corrective lenses by age (p=0.000).*

The results indicate that the highest rates of back disorders occur in overweight and obese subjects (*p*=0.000) (Table 5).

Table 5. *BMI categories and spinal disorders (p=0.000).*

BMI categories		Spinal disorders			Total
		No	Scoliosis	Hyperkyphosis	
Underweight	N	116	21	10	147
	% Spinal disorders	5.2%	4.4%	4.0%	5.0%
Healthy weight	N	1575	359	98	2032
	% Spinal disorders	70.5%	76.1%	39.0%	68.7%
Overweight	N	402	68	76	546
	% Spinal disorders	18.0%	14.4%	30.3%	18.5%
Obese	N	140	24	67	231
	% Spinal disorders	6.3%	5.1%	26.7%	7.8%
Total	N	2233	472	251	2956
	% Spinal disorders	100.0%	100.0%	100.0%	100.0%

However, the level of obesity and use or non-use of lenses showed no significance (*p*=0.060) (Table 6).

Table 6. *BMI categories and corrective glasses (p=0.060).*

Glasses		BMI categories				Total
		Underweight	Healthy weight	Overweight	Obese	
No	N	133	1771	470	213	2587
	% Obesity	90.5%	87.2%	86.1%	92.2%	87.5%
Yes	N	14	261	76	18	369
	% Obesity	9.5%	12.8%	13.9%	7.8%	12.5%
Total	N	147	2032	546	231	2956
	% Obesity	100.0%	100.0%	100.0%	100.0%	100.0%

DISCUSSION

The 2,956 participants in this study were distributed evenly by gender (50.1 % boys and 49.9 % girls) and age, in the samples studied from Granada and its province, with a mean age of 9.61 and a typical deviation of 1.211.

Firstly, for the degree of obesity variable, 26.3% (n=777) of the participants showed levels of obesity (overweight and obese). These figures show that a quarter of the sample analysed presented obesity values. The figures obtained regarding those found to be overweight (18.5%) agree with the findings of the Autonomous Government of Extremadura Consumer Department (2007) and are lower than those provided by Gómez et al., (2006). The proportion of obese schoolchildren identified in this study (7.8%), is similar to the results provided by Muñoz et al., (2006) and Poletti et al., (2007), who found the prevalence of obesity to lie between 5% and 10% for schoolchildren from different countries. However, this result differs from studies by Gómez et al., (2006) and Alconero et al. (2006), who found prevalences of 23.9% and 11.1% respectively. In light of the above, the figures appear to indicate a high prevalence of the degree of obesity in the population as a whole. It would therefore be as well to remember the harmful effects this variable has on the general state of health (Jebb et al., 1999; Wearing et al., 2006; Yosipovitch et al., 2007).

Regarding the spinal disorders, the values found in this study identified 16% pupils with scoliosis. These results agree with those provided by the Aragon Autonomous Government, 1999, and other writers (Álvarez et al., 1988; Redondo et al., 1999; Ostojic et al., 2006). However, other researchers have obtained different figures (Vitores, 1990; Koukourakis et al., 1997; Yawn et al., 1999; Skaggs et al., 2006), which can be attributed, amongst other things, to the different methodologies used. The rate of scoliosis found in this study is similar to that described by other authors who signal the relationship between lateralisation of the spine and age.

As regards the results of the hyperkyphosis variable, which reached 8.5% (n=25) in this sample group, certain studies coincide with this finding (Ascani et al., 1977) whilst others do not (Nissinen et al., 1995; Rodríguez, 1998; Marín et al., 2004; Lalic et al., 2006). For example, authors such as Aragón (1999) and Redondo et al. (1999) found prevalence of hyperkyphosis in samples of the Spanish population of between 3% and 4.92%. These results also show that hyperkyphosis and a hyperkyphotic attitude may be the result of bad posture at school and a lack of physical activity (Nissinen et al., 1995).

Regarding the variable referring to those who use glasses and those who do not, very different values were observed between those who did not use glasses and those who did (87.5% and 12.5% respectively). It should be mentioned that the prevalence of myopia found in this study was similar to the levels described by De Amorin et al., (2005), Tarczy- Hornoch et al., (2006) and Sorel et al., (2007) with values varying between 10% and 15%.

For the obesity variable and its relationship with sex and age, statistically significant differences are observed (p=0.000 and p=0.000). Thus, by sex, females showed higher obesity values (9.50%) than males. In 2004, Garagorri commented that this difference could be attributed to the fact that girls are more prone to obesity at such an age, as they generally carry out less physical activity. On the other hand, the differences in the relationship between obesity and age found in this study (See Results section) and confirmed by Bras (2005), could be explained by such variables as correct eating habits and low activity levels (Salas et al., 2006; Warnberg et al., 2006).

With regard to the sex and age variables and their relationship with spinal disorders, statistically significant differences were found in both cases (p=0.002 and p=0.003). More males had scoliosis (57.6%; n=272) than females (42.4%; n=200). These results are similar to those obtained by De la Cruz et al., (2001) and Marín et al., (2004), but are different to the studies carried out by Rogala et al., (1979) Shands et al., (1995), Soucacos et al., (1997) and Gopen (2002), who found a higher prevalence of scoliosis among females. The greater number of boys with scoliosis may be due to social factors and a lack of supervision at school It should be highlighted that females are more likely to take measures to prevent spinal disorders (using a bag with wheels rather than a rucksack, better posture, etc.), as stated by Grimmer et al., (2002) and Kovacs et al., (2003). No statistically significant differences were found regarding hyperkyphosis and gender.

The distribution of spinal disorders by age was highly heterogeneous for all age groups, with the disorder levels detected in 12 year olds the most significant. These results can be supported by such authors as Wong (2000), Gopen, (2002) and Kovacs et al., (2003), who refer to an increase in spinal disorders between the ages of 11 and 12, coinciding with the "surge" of puberty. In this sense, it is probable that vertebral structures do not adapt as well as could be hoped to the excessively fast growth of other structures related to the spinal column.

As regards the level of obesity and spinal alteration variables, highly statistically significant differences appeared (p=0.000). Thus, of the 251 individuals with hyperkyphosis, 57% (n=143) had obesity levels above normal (Healthy weight), values confirmed by Harreby et al., (1995) and Serra et al., (2003). These figures should be taken into consideration as, if hyperkyphosis is understood to be characterised by stiffness of the muscular, facial and skeletal structures of the body that cause, amongst other things, pain generally located at the back of the torso, this situation may cause reduced physical activity, an increase in sedentarism and a possible increase in obesity levels (Harreby et al., 1995).

CONCLUSIONS

- The population sample studied showed overweight and obesity levels (26.3%), especially in females. In this respect, the authors recommend that physical exercise and health programmes be developed to help prevent health problems related to overweight and obesity.

- The population sample studied with spinal disorders (24.50%) contained more individuals affected by scoliosis (16%) than by hyperkyphosis (8.5%), and the latter presented a higher percentage of obesity.

- The population sample studied showed ocular disorders (12.5%).

- Further studies are required to identify the causes and most effective procedures for preventing and treating spinal alterations in children.

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