Original Article

The Prevalence of Trunk Asymmetries in the small Island state of Malta

Mark Sacco, Michela Catania

Abstract

Background: Malta, the smallest member state of the European Union is constituted of two inhabited islands Malta and Gozo. In the Maltese islands there has not been any large population size definitive study concerning the incidence of trunk asymmetries that may indicate Adolescent Idiopathic Scoliosis (AIS) amongst the general population. Scoliosis is one of the most deforming orthopaedic conditions confronting children. To confirm the orthopaedic condition of scoliosis one has to carry out a visual examination that usually consists of the Adam's Forward Bend test, this is followed by the measurement of trunk rotation with the use of a Bunnell Scoliometer. Should the angle of trunk rotation be more than five degrees then the positively screened student be referred for x-Rays and a 10 degree Cobb angle taken as being required to confirm the diagnosis of Scoliosis. The lack of a full scale study together with the apparent lack of awareness regarding the condition has prompted the authors to research the situation on all Gozitan children aged between 13 and 15 years of age.

It was decided to measure Trunk Asymmetry and the aim of the study was to obtain statistical data on the occurrence of trunk asymmetries amongst the Gozitan population, to further analyse the ratio of distribution of trunk asymmetries between female and male students and finally to refer the positively screened students to the relevant medical authorities for x-ray to confirm a scoliosis diagnosis.

Methods: This quantitative study design was carried out on all children aged between 13 to 15 years old over a five-month period. An Adam's forward bend test and Scoliometer reading were taken for each participant consenting to this study. To minimse bias a qualified full time Physiotherapist graduated with a Bachelor of Science Honours degree in Physiotherapy since 2012, carried out these tests in the selected schools.

Results: The results of the study concluded that 5.3% of the adolescent population in Gozo suffer from trunk asymmetries (13 out of 245). Prevalence of trunk asymmetry was calculated using the 95% confidence interval and the Chi square tests had a significant p-value. Further analysis showed that 69% of these were female and 31% were male. These results demonstrate that the prevalence of trunk asymmetries in Gozitan adolescents is comparable to that stated within the current literature.

Conclusions: Results from the study confirms that trunk asymmetry is relatively common within the Maltese population. This might be indicative that a significant portion of the Maltese adolescent population might suffer from Adolescent Idiopathic Scoliosis. The intention of this research is to increase the general public's awareness of the condition AIS, to make this condition more prominent to members of the allied professions, to reinforce the need for school screening projects and finally to ensure that the condition Trunk Asymmetry and Scoliosis is given the importance that it requires in the curriculum of study for physiotherapists.

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Keywords

Adolescent Idiopathic Scoliosis, Trunk Asymmetry, Cobb Angle, Prevalence, Scoliometer, Adam Forward Bend Test

Background

The total population of the Maltese islands is 429,344. According to the demographic review in 2015, Gozo has a population of 15,624 males and 15,822 females creating a current population of 31,446 inhabitants. Due to its geographic status and its small population size it can be considered an entire entity and the whole population of a particular age group can be researched. AIS being a common orthopaedic condition that effects a percentage of any population warrants further investigation. This has led the researchers to study the prevalence of asymmetrical trunk rotations that can be referred for further radiographic investigations within the Gozitan population in an effort to quantify the condition scoliosis. A high incidence of asymmetrical trunk rotation that might equate to an increase in the diagnosis of scoliosis may suggest it to be included within the physiotherapy curriculum. Also an early diagnosis of the asymmetrical trunk rotation and an early intervention by a physiotherapist may result in amelioration or preventing further complications that may lead to this condition scoliosis or surgery.

Scoliosis has been described as one of the most deforming orthopaedic problems confronting children (Pavlu et al., 2009). According to the National Scoliosis Foundation (NSF), scoliosis affects 2 - 3% of the population, or an estimated 6 million people in the United States (National Scoliosis Foundation, 2019).

Scoliosis is, ‘’a three dimensional torsional deformity of the spine and trunk’’ (Grivas et al., 2008) According to Konieczny, Senyurt and Krauspe (2013) adolescent scoliosis develops at the age of 11-18 years and accounts for approximately 90% of cases of idiopathic scoliosis in children (Konieczny et al., 2013).

Patients suffering from scoliosis are typically classified according to cause. Congenital scoliosis is an abnormality in the vertebral column, which may lead to progressive spinal deformity. On the other hand neuromuscular scoliosis, is a deformity caused by an abnormality of the central nervous system (such as spastic quadriplegia) or the peripheral nervous system (such as muscular dystrophy) or a combination of both the sensory and motor nerves (such as syringomyelia). Degenerative disc disease has also been attributed as a cause to the development of scoliosis in adults. Certain connective tissue diseases and patients suffering from neurofibromatosis are also prone to having this condition. However the commonest cause of scoliosis is idiopathic. Idiopathic scoliosis is further sub classified as infantile when a child up to 3 years of age is affected; juvenile when a child up to 10 years of age is affected and adolescent scoliosis affecting children over 10 years of age (Hresko et al., 2013).

Not all trunk asymmetries are classified as scoliosis, curvature of the spine may be related to various factors. In fact, cobb angle of $\geq 10^{o}$ is regarded as the minimum angulation to define a curvature in the spine as scoliosis. (Konieczny et al., 2013).

The aim of this research study was:

1. To obtain statistical data on the occurrence of trunk asymmetries amongst the Gozitan population in both male and female students between the ages of 13-15 years.
2. To determine the ratio of distribution of trunk asymmetries between female and male students.

Method

Population

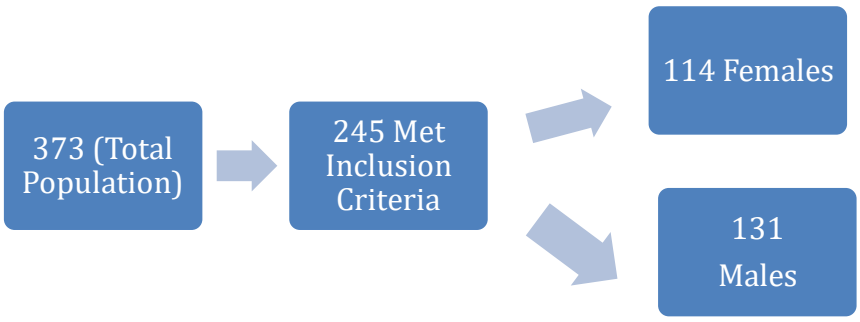
Following approval from the Department of Education, each Head of School was approached and approval obtained to carry out the study. An information letter together with a consent form was distributed to all students by members of staff from the schools. The premises that the examinations took part were identified all having privacy, good lighting, adequate space and considered to be safe. Each student was asked to enter the room individually. All students were advised to wear appropriate clothing, changed and examined in the presence of a teacher. The floor was marked with a horizontal line indicating were the students had to stand.

All school children aged between 13-15 years (373 students) were invited to participate in the study. The whole of the age group population chosen was used for the findings of this study. A random selection did not to be used owing to the small Gozitan population.

The reasons behind this age bracket being chosen were that; according to WHO, the period between the ages of ''10-19 years'' are adolescence years. Thus, this study commenced at 13 assuming that should there be a spinal deformity present; this would be picked up during the screening process (Scoliosis Research Society, 2019). This reasoning also led to the cut off point of 15 years as literature supports the fact that most scoliosis patients will have an element of deformity present by this age, being the age at which changes at the spine commonly occur (UCLA Spine Centre,2016). The cohort in the study were Caucasian.

The inclusion criteria included all 373, 13-15 year old students in state and church schools, who were Maltese citizens living in either Malta or Gozo for the last ten consecutive years. Another inclusion criteria is that they needed to be capable of standing and bending forward unaided. Out of these 373 students 178 were female and 195 were male. 245 students met the inclusion criteria, thus the percentage population for this study was 65.7%, out of which 131 were males and 114 females (see figure 1 breakdown of population sample).
Children without parental consent were excluded.

***Figure 1**: Breakdown of population sample*



Procedure

All participants performed the Adam Forward Bending Test with the hands clasped and trunk asymmetries were measured by a Bunnell Scoliometer

The students were first observed in the standing position and asked to stay in their natural standing position with their arms by their sides. Any abnormalities or asymmetries were noted. The participants were then asked to place their feet on the markings present (10 centimetres apart). They were instructed to grasp their hands with their elbows straight and to bend forwards as far as they could go, keeping their knees straight. At this stage they were observed at eye-level in this position from the back and side. If a rib hump was observed then a Scoliometer was placed along the spine with the '0' mark at the top of the spinous process and the greatest reading noted. For the purpose of this study an angle of more than 7 degrees was taken to be positive for scoliosis. As Grivas et al states in his study in 2002, ''a Scoliometer reading of 7 degrees should be an indication for radiographic evaluation of the whole spine. The Scoliometer threshold reading of 7 degrees or more is used by the majority of practitioners''. This procedure on average took four minutes, with female students taking slightly longer. All students in which a trunk asymmetry of a 7 degree Scoliometer reading was noted, were given a pre-prepared letter informing their parents/guardians about the results and advised to seek medical assistance (Grivas et al., 2002).

The Scoliometer is known to have a high inter-rater reliability and validity. According to Murrell

et al., study in 1993 intra-rater reliability for the use of the Scoliometer has been described as outstanding and thus reliable to use, being a reproducible tool that can compare easily (Murrell et al., 1993). This was further confirmed by Bonagamba et al., in 2010 (Bonagamba et al., 2010). Therefore it is a useful tool when used in screening programmes. Traditionally, screening procedures relied heavily on the forward bend test but this only offers subjective examination. One scoliometer measurement alone does not stand instead of radiographic Cobb angle measurements and therefore, clinicians should not use the Scoliometer exclusively as a diagnostic tool. Having said that a recent study in 2017 has shown that '' The maximal trunk rotations at the thoracic and lumbar regions were recorded with a scoliometer. Right asymmetry hump was deemed positive (+), and left asymmetry hump was deemed negative (−). The Cobb angles were measured with a Picture Archiving and Communication System. Statistical analysis included Pearson's correlation coefficient, multivariate regression and Bland–Atman analysis…Based on the results of these two-parameter formulas for thoracic and lumbar curves, the Cobb angles can be predicted more accurately by the readings of the scoliometer. Physicians and other healthcare practitioners can thus evaluate patients with scoliosis more precisely than before with a scoliometer'' which can be a worthy indication of use for future studies (Ma et al., 2017)

Data analysis

The chi-squared test was used to evaluate whether there was a significant association between gender and a significant trunk asymmetry. Therefore it was used to find whether scoliosis is more likely to be common in males or females. This test was used to determine prevalence and compare findings using the Statistical Package of Social Sciences (SPSS) through the inputting of raw data. Descriptive analysis was used to interpret results.

The Prevalence of trunk asymmetry was calculated using the 95% Confidence Interval formula, confidence interval (CI) = ± z σp of which:

1. P is the sample proportion which is

$$= \frac{\text{Number of positive findings}}{\text{Total sample size}} = \frac{13}{245} = 0.0531$$

2. z is a constant = 1.96 assuming a 95% confidence interval
3. σp is the standard error = $\sqrt{p(1-p)/n}$ x (N (total population 373)-n (sample size 245)) / (N-1)

Results

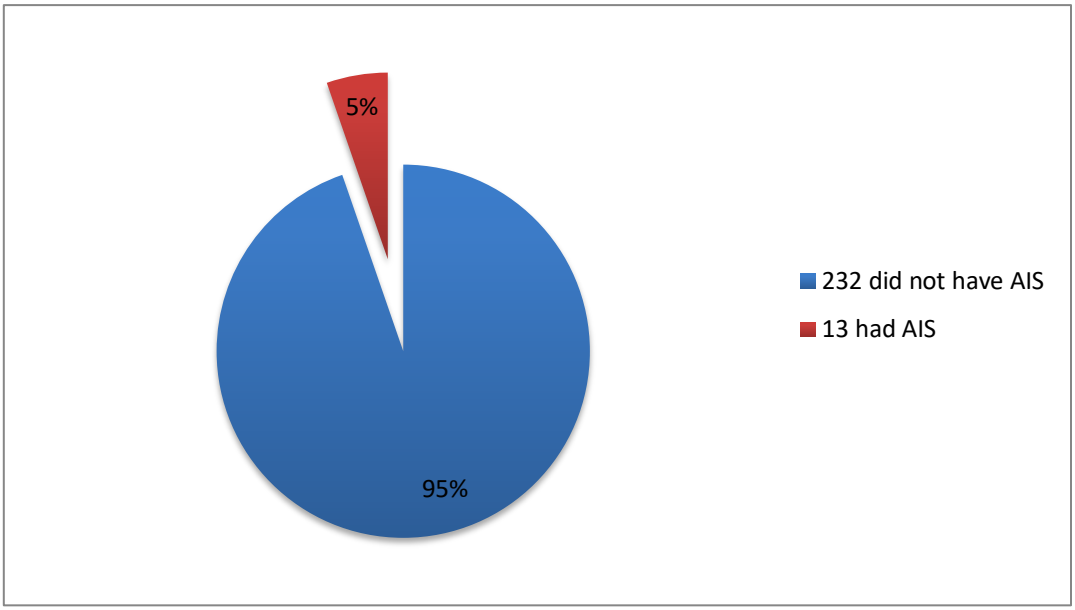
The findings from the research concluded that 13 adolescents had a positive result (see Figure 2), which was determined by a reading of trunk asymmetry of 7 degrees or more on the Scoliometer, together with a positive Adam Forward Bending Test. Thus, the Prevalence of students with trunk asymmetries in Gozitan children was found to be 5.3% within this age group. "Further analysis of the data revealed that the prevalence of trunk asymmetries was higher in the females *(N=9)* than in the males, as found to be 79% is to 31% respectively *(N=4)*". Thus the female to male ratio was 9:4 which is equivalent to 2.25:1 (see Table 1).

Table 1*: Prevalence of trunk asymmetries in male and female children*

	Males	**Females**	**Total**
Number of Trunk Asymmetries	4 (31%)	9 (69%)	13 (100%)
P Value			0.092

The research result of 5.3% demonstrated a 95% confident that the prevalence of trunk asymmetry is between the lower (3.66%) and upper (6.96%) limits of the 95% confidence interval of the prevalence. These readings, if confirmed by further radiographical examination or two parameter scoliometer vales may further confirm and quantify the presence of scoliosis amongst Gozitan adolescents aged 13-15 years.

***Figure 2**: Total Sample Population*



The CI was calculated using the formula CI = ± z σp. The Chi Square P value was calculated to be 0.092, whilst the σp was calculated to be 0.0084 (√ (0.0531)(1-0.0531) / 245 x (373-245) / (373-1)). Therefore the confidence Interval = pbar z σp
= 0.0531 + 1.96 (0.0084) = 0.0366
And
= 0.0531 – 1.96 (0.0084) = 0.0696
Therefore 0.0366 < *p* < 0.0696

Since the p-value lies in between the lower and upper limits of the 95% confidence value we can conclude that readings are 95% confident of findings.

Discussion

Presently there is little evidence or literature supporting the prevalence of trunk asymmetries and scoliosis in children in Malta or Gozo. The two studies that have been carried out so far (Sultana 2001 and Spiteri et al., 2005), appear to have substantial weaknesses in the research methodology including varying definitions of scoliosis, the rigour of the study protocol, a small sample size, different age-groups, and different research tools.

A small study on Maltese students aged 10 to 14 using the Adam Forward Bend Test and Scoliometer concluded that 24.1% tested positive to the forward bend test (Sultana, 2001). Sultana in 2001 carried out a study on 676 students taking 7 degrees as the angle of trunk asymmetry with 32 (4.7%) being diagnosed as having this. He goes on to state that the female to male ratio was 5.4:1 (Sultana, 2001). This study was carried out on two schools and hence the sample as compared to the total population in Malta may have been too small although the total sample was larger than that carried out in this study. The researcher was the individual actually carrying out the readings hence an element of bias might have been included. However the results from this study are relatively similar to another carried out in Malta by Spiteri et al in 2005. In this other study, the Department of Orthopaedic Surgery in St. Luke's Hospital Malta, concluded that out of a population of 611 patients already diagnosed with scoliosis aged between 10 and 16 years, 344 of them were diagnosed as having adolescent idiopathic scoliosis with the scoliometric angle being taken as greater than 5 degrees. The Incidence from this study was of 0.69% for females and 0.15% in males hence the female to male ratio was 5:1 similar to that of Sultana in 2001 (Spiteri et al., 2005).

The authors in this study acknowledge the fact that a Scoliometer was the tool used to measure the angle of the deformed spine and that scoliosis can only be diagnosed by means of radiographic measurements. Hence the results from this study measure trunk asymmetry and are an over estimation of scoliosis prevalence. Only a percentage of the participants who presented with a curve measured by the Scoliometer are likely to be

diagnosed as suffering from scoliosis. In a bid to prevent children being exposed to unnecessary x ray exposure the use of a Scoliometer as the research tool was solely used to measure trunk asymmetry. This article is the first step towards further studies for radiographical evidence

In comparison to the previous results this study concluded that the prevalence of trunk asymmetry amongst 13 – 15 year old Gozitan children is of 5.3%, with a female to male ratio of 2.25:1. This percentage result may appear relatively high when compared to other countries that have carried out prevalence studies but unfortunately very hard to compare as the study has only measured trunk asymmetry. This is due to the fact that very few countries especially those bordering the Mediterranean Sea have published any studies concerning trunk asymmetry and the fact that there is still such a discrepancy at which angle AIS is diagnosed. Seven degrees of trunk asymmetry was taken as the deciding angle to refer for further radiographic investigations. Hence, the relatively high incidence of trunk asymmetries generated from this study could have resulted in a lower incidence of scoliosis when comparing to the same ranges of other countries and studies.

Prevalence of trunk asymmetry also depends on the age and gender of the population being studied and modern literature supports the fact that the incidence of trunk asymmetry is higher in females and is genetically determined (Wynne-Davies, R., 1968). Gozo being a very small island with a relatively high population could lend itself to a certain amount of inbreeding which might have influenced the prevalence of trunk asymmetries and possibly scoliosis. These three reasons could also be the possible cause why these results showed a higher likely incidence of AIS in Gozo when compared to other larger countries or studies.

The uniqueness of this research is that even though at face value the research population looks small, this study was not carried out on a sample of a population, but on all the 13 to 15 year olds of the island's population. Results from this study did not concur with Adobor (2011) who stated that there is a higher prevalence of AIS in the northern European geographic latitudes and lower in southern countries (Adobor et al., 2011), possibly due to what Grivas, et al. stated in 2006, that there might be a link between hours of sunshine, commencement of menarche and prevalence of AIS (Grivas et al., 2006). Adobor's study on a total population of 4000 concluded that 1.5% or 60 presented with a positive Scoliometer test of more than 7 degrees. However only 0.55% or 22 where found to have true scoliosis that were confirmed by x ray examination with a cobb angle of more than 10 degrees. Another study in a northern country confirmed a low incidence, which was carried out by Willner and Uden (1982) regarding the prevalence of AIS in southern Sweden. In this study, 17,181 concluded that 108 (0.6%) were found positive with a cobb angle of 10 degrees taken as the lower limit to diagnose scoliosis (Wilner et al., 1992). On the other hand another study in Finland has contradictory results as they recorded high levels of incidence (Nissinen et al., 1993). Nissinen et al., in 1993 carried out a study on 855 school children and 29.2% were found to have trunk asymmetry that were further examined by means of radiography to confirm that the prevalence of scoliosis taking a cobb angle of more than 10 degrees was of 9.2%.

Another study conducted in Greece which can be considered as a southern country by Soucacos et al., in 1997 had 82,901 children participating (41,939 boys and 40,962 girls) of ages between 9 to 14 years. Results revealed that 4,185 (5%) having a positive forward bend test led to further investigation by means of x rays confirming that scoliosis was present in 1.7 % of the population with a cobb angle of 10 degrees or more (Soucacos, et al., 1997). Replicating this study in Gozo also resulted in a higher prevalence similar to the above study by Soucacos et al., when compared to the statement by Adobor et al., that the incidence of AIS in northern countries is more prevalent than that of southern countries. In fact, this research resulted in 13 out of 245 (5.3%) having trunk asymmetry. This is similar to that conducted by Soucacos et al., (5%) in Greece. However these results in the Maltese Islands where not further investigated by means of x rays to confirm the incidence of scoliosis. Still, these results do not reflect the study in Sivas, Turkey, by Cilli et al., carried out in 2009 with a population of 3,175. Results from a forward bend test and palpation of the spine resulting in an incidence of scoliosis at 0.47% and a female to male ratio of 2:1. Yet not confirmed by radiographic studies (Cili et al., 2009). Ugras et al. (2010) on the other hand determined the prevalence of scoliosis and the cost

effectiveness of a school screening programme also in Turkey taking a cobb angle of more than 10 degrees on a research population of 4,259 children aged 10-14 years showed a prevalence for AIS of 2.5%, with a ratio of girls to boys of 2.5:1 (Ugras et al., 2010) (see Table 2 for a summary of findings).

Table 2: *Summary of findings*

Malta, 2001. Forward bend test and Scoliometer (Sultana 2001)	Reviewed 676, 24.1% positive
Malta 2005. Scoliometer (Spiteri et al., 2005)	Reviewed 611 with scoliosis, 344 positive
Norway, 2011. Adam Forward Bending Test and measurement of gibbus using a scoliometer. (Adobor et al., 2011)	Reviewed 4000, The prevalence of idiopathic scoliosis defined as a positive Adam Forward Bending Test, gibbus > 7° and primary major curve on radiographs > 10°, was 0.55%
Greece, 2006. The scoliometer readings in both standing and sitting position (Grivas et al., 2006)	Reviewed 2071, The mean difference of frequency of asymmetry (ATR > 0 degrees) at standing minus sitting forward bending position for boys and girls was 10.22% and 9.37%, respectively. The mean frequency of asymmetry of 7 or more degrees was 3.23% for boys and 3.92% for girls at the standing forward bending position and 1.62% and 2.21% at the sitting, respectively.
Sweden, 1982. Children with clinical signs of scoliosis including a positive forward bending test were admitted to the Department of Orthopedic Surgery for reinvestigation and AP roentgenograms. (Wilner et al., 1992)	Reviewed, 17181. There were 474 children with a scoliosis measuring 5 degrees of more (prevalence 2.8 per cent).
Finland, 1993. Trunk asymmetry was measured by the forward bending test and moiré topography. A posteroanterior standing radiograph of the spine was taken of those 250 (29.2%) children who had a trunk hump > or = 8 mm. (Nissinen et al., 1993)	Reviewed, 855. Only 8.3% of the children were found to be symmetric (hump 0-2 mm) in the forward bending test: 65.5% had a hump of 3-7 mm and 26.2% had a hump > or = 8 mm at 13.8 years.
1997, Greece. Forward bend test and radiographs (Soucacos et al., 1997)	Reviewed, 82,901. Five thousand eight hundred and three children had clinical signs of scoliosis and, of these, 4185 were referred for posteroanterior radiographs (to be made with the patient standing) because they had a positive result on the forward-bending test
Turkey, 2009. Forward bend and palpation (Cili et al., 2009)	Reviewed 3175. 6 to 8 were selected from 16,103 students using a stratified sampling method, 15 positive
Turkey, 2009. Forward bend and radiographs (Ugras et al., 2010)	Reviewed 4259. Prevalence of 25/1000. Thirty-nine children (0.91%) from sample population displayed abnormalities on the bending test, and 29 children (0.68%) came to our hospital for further evaluation (Table 1). Eleven of these (0.25%) showed radiographic evidence of abnormal curvature.
Korea, 2011. Scoliometer reading ≥5° were referred for radiograms. (Suh et al., 2011)	Reviewed 1,134,8. 37,339 of them had positive results with Cobb angles ≥10°

Singapore, 2005. Those with scoliometer readings of more than 5 degrees underwent radiographic evaluation (Wong et al., 2005)	Reviewed 72,699. Prevalence rates were 0.05% for girls and 0.02% for boys at 6 to 7 years of age, 0.24% for girls and 0.15% for boys at 9 to 10 years of age, 1.37% for girls and 0.21% for boys at 11 to 12 years of age, and 2.22% and 0.66%, respectively, for girls and boys at 13 to 14 years of age
1997, Crete. Scoliometers are used for the selection of children who should be referred for radiological evalutation (.7 degrees) (Koukourakis et al., 1997)	Reviewed 21,220 chldren, 9.6% were referred for radiological examination; 1.7% of the screened children were found to have sine deformities with angular values >10 degrees. The prevalence of severe abnormalities (.20 degrees) requiring conservative treatment was 0.06%. Thirty percent of the scolioitc deformities involved the thoracolumbar region, whereas 48 and 22% of curves were confined to the thoracic or lumber area respectively.

There are numerous other studies in the literature from outside Europe that demonstrate a varying percentage incidence of AIS, the following two are just two examples that are being quoted to serve as examples. The large study by Suh et al., conducted in Korea in 2011 with a research population of 1,134,890 children participating (584,554 boys and 550,336 girls) showed an overall prevalence of 3.26% and a female to male ratio of 2.2:1, however the decisive angle defining AIS was taken as more than 5 degrees (Suh et al., 2011). In Singapore, taking a Cobb angle measurement of 10 degrees on a total population of 37,141 Wong et al 2005 report a prevalence of 0.93% range (Wong et al., 2005).

The study that is closest to this research must be that by Koukourakis et Al. in 1997 in Crete, as both countries are islands situated in the Mediterranean Sea, approximately on the same longitude. Trunk asymmetry was found to be present in 9.6% with a Scoliometer reading of 7 degrees, whilst 1.7% found to have scoliosis of more than 10 degrees (Koukourakis et al., 1997). The literature has shown that the prevalence of trunk asymmetry in Northern countries was between 1.5% and 29.2%. While in southern countries it was that of 5% to 9.6%. Hence this study with an incidence of 5.3% is similar to the literature findings.

Conclusion

This study has concluded that the overall prevalence for trunk asymmetry taking a defining angle of 7 degrees within a total population of the island of Gozo was 5.3%. However these results are not definitive confirmation of diagnosis of the condition scoliosis but indicative. All children who presented with these results were asked to have further investigations to confirm the diagnosis. Results from the study reconfirm that there is a high incidence of trunk asymmetry, within the Maltese population. Thus the knowledge and treatment about this condition that could lead to AIS should be included within the local physiotherapy curriculum, taught at the University and the results made public to the local physiotherapy association that can influence the early intervention by the physiotherapist in preventing further complications that may lead to surgery.

Furture Recommendations:

1. Further studies comparing rates in different counties would be interesting.
2. This study could also be taken further into analysing results using the two parameter Scoliometer screening.

List Of Abbreviations

AIS: Adolescent Idiopathic Scoliosis

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