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Epidemiology of spinal deformities among secondary school children in Rwanda

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Abstract

In children, poor posture is caused by many factors including, malnutrition and altered habitual positions. Poor postures may develop into fixed spinal deformities, and could negatively affect the physical and psychological well-being of children. In this study, we examined the screened prevalence of spinal deformities and characterized the type and distribution of deformities in 3 606 (mean age 19.3±2.1) Rwandan secondary school children. We screened the postures of children using the Modified Posture Screen test and the Adams Forward Bend test. Relationships between categorical variables and spinal disorders were investigated with the Chi-square test. The screened prevalence of spinal deformities was 53.3% (95% CI 51.7; 55). Scoliosis was most the common deformity at 39% (95% CI 38%; 41%). Female gender (p = .029) and low body mass index (p = .002) were significantly associated with the presence of spinal deformities. Our finding points to the need for a follow up evaluation during which positively screened children undergo clinical examination and treatment as needed. At the population level, educators and nurses should be trained to screen for spinal deformities, to ensure that all schoolchildren in Rwanda have access to proper screening and necessary intervention.

Keywords: Screening, spinal deformities, Rwandan children.

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Introduction

The axial musculoskeletal structures are organized so that muscles work efficiently, internal organs are protected, and the human body can function in an upright manner (Penha, João, Casarotto, Amino & Penteado, 2005). This manner of organization is termed posture, and when posture is disrupted, it may result in abnormal patterns of movement, physiologic changes and permanent deformities (Stroebel, 2008). Impaired posture may also mar the psychosocial health of adolescents as body image is associated with self-esteem (Gallant et al., 2018). Eventually, these factors could also limit children's levels of interaction thereby stifling character development (Stroebel, 2008; Van Den Berg, Mond, Eisenberg, Ackard & Neumark-Sztainer, 2010).

Structurally, the spinal column encompasses normal lordotic-kyphotic-lordotic curvatures of the cervical, thoracic, lumbar and sacral regions (Sater, White & Haynes, 2007). Deviations from the normal structure involve both translational and angular asymmetry of the vertebrae, the rib cage and the back surface; leading to a loss of spinal balance and can produce a sideways tilt or forward and backward imbalances (Sater et al., 2007). These deviations are known as scoliosis, kyphosis in excess of normal or lordosis in excess of normal. Scoliosis involves a lateral curvature of the spine with rotation of the vertebrae within the curve, which when measured on X-ray, is greater than ten degrees (Grivas et al., 2010). Scoliosis can be divided into two categories: structural and functional. In structural scoliosis, bony changes in the alignment of the vertebrae result in fixed abnormal curvature. In functional scoliosis, the shape or structure of the spine is not permanently changed but the asymmetry cannot be completely corrected. Kyphosis is a posterior convex angulation of a section of the spine and is abnormal when it goes beyond the normal range of 20 to 45 degrees. Lordosis is an anterior convex angulation of a section of the spine and is abnormal when the measurements exceed 25 to 60 degrees (Ball, Cagle, Johnson, Lucasey & Lukert, 2009).

In many countries, children are routinely screened for postural abnormalities (Adobor, Rimeslatten, Steen & Brox, 2011; Jehle & Kühnis, 2011; Ueno et al., 2011; Ugras et al., 2010). From these studies, it is evident that the prevalence of spinal deformities varies widely, for example, an estimated 0.5% to 3% of school children in Brazil have spinal deformities, whilst 12% of adolescents in the Netherlands reportedly had spinal deformities (Nery, Halpern, Nery, Nehme & Tetelbom Stein, 2010). Such variability in the prevalence of spinal deformities indicates a need to conduct national screening studies so that public health efforts are implemented to treat and or prevent further dysfunction. Few studies have described the burden of spinal deformities in African school children (Ellapen & van Heerden, 2011; Fazal et al., 2013; Wilders et al., 2009), and none from Rwanda.

Rwanda is unique, both in terms of public health initiatives, and in its progress toward achieving the millennium development goals for health (Abbott, Sapsford & Binagwaho, 2017). With the rates in child mortality declining, maternal health improving and the burden of infectious disease dropping, Rwanda is ready to address often overlooked health issues, such as the musculoskeletal health of its children. In this study, we investigate the screened prevalence of spinal deformities in secondary school children in Rwanda to examine the need to develop spine-related health promotion programmes in schools.

Methodology

Study setting and design

Using a cross-sectional design, we screened learners enrolled in 15 secondary schools, out of 1 502 secondary schools which enrolled 566 378 secondary learners in Rwanda (Ministry, 2014). Schools are funded privately, publicly or receive a partial government subsidy (parents-association schools) (Table 1).

Population and sampling

A multi-stage sampling method was used as follows: (1) Purposive sampling of three of the five provinces to represent the most rural and the most urban schools, we chose provinces with the highest density of schools, (2) we randomly selected one school in each province, (3) we used also snowball sampling to select four more schools close to the randomly selected schools, (4) and screened all students from Senior 5 (S5) and Senior 6 (S6) classes (n=4 999), who voluntarily gave informed consent. Students in S5 and S6 were included because deformities of the spine mostly develop during the pubertal growth period (Poussa et al., 2005).

Instrumentation and apparatus

Students were screened according to the following fields: demographic (age, gender, province, class stream), biographic (height, weight) variables and spinal deformities (hyperkyphosis, hyperlordosis, scoliosis or normality). Spinal deformities were identified with the relatively quick, cheap, safe and simple Adams Forward Bent Test (FBT) which was performed using a plumb-line held at cervical vertebral level 7 (C7) as described by Côté, Kreitz, Cassidy, Dzus and Martel (1998).

The FBT is a suitable screening method with a specificity of 93% and sensitivity of 84%. However, it yields more false-negatives and fewer false-positives compared to the scoliometer, humpometer, and Moiré topography (Karachalios et al., 1999). Disrobed students were viewed from six positions described by Côté et al. (1998).

Reliability and validity

Comparison of the validity and reliability of the scoliometer and Adam's FBT revealed that Adam's FBT was more sensitive than the scoliometer in detecting thoracic curves measuring 20 degrees or more using the Cobb method. Both tests had adequate inter-examiner reliability for the assessment of thoracic curves (Côté et al., 1998).

Procedure

Ethical clearance was obtained from the Kigali Health Institute (KHI) Institutional Review Board (Nr: KHI/IRB/26/2010), and the Ministry of Education in Rwanda granted permission to conduct the study. Parents signed informed consent forms and children gave assent. The researchers conducted initial entry and planning visits to all participating schools to obtain permission from key stakeholders and arrange the logistics of the screening programme.

The researchers recruited and trained research assistants (n=17). All 20 team members (3 principal researchers and 17 research assistants) visited each school. Data were collected in one day at each school to make a total of 15 days. Three sub-teams of four research assistants each was allocated a specific task (e.g. measuring height and weight, observing for the deformity), and the same researcher consistently made the final decision about the categorization of spinal deformities, both functional and structural.

Data analysis

Data were entered into Epi Info 3.5.3 and analysed using Stata/SE 10. Descriptive statistics for all variables were computed. Continuous variables were summarised with mean and 95% confidence intervals (CIs). Frequency, proportions and 95% CIs were used to summarise categorical variables. The Chi-square statistic was used to analyse the relationship between clinically relevant categorical variables and was deemed significant if $p \leq .05$.

Results

In total, 3 606 out of a possible 5 062 students participated in the study (participation rate: 71%), of which 54% and 45.9% were in S5 and S6, respectively. Participants were evenly distributed across public, private and government-aided schools (Table 1). The participants' mean age was 19.3±2.1 years (range: 11 to 34 years), and 2 587 (51.1%) were males, and 2 475 (48.9%) females. Of the 3 606 students, 64.8% were enrolled in science courses, 18.9% in Accounting and 16.3% in the Arts.

The prevalence rate of posture deformity among the students was 53% (1 911) (95% CI 0.51; 0.54). Table 2 illustrates the distribution of the students' spinal characteristics. The spinal disabilities detected in the students included scoliosis (55%), hyperkyphosis (22%) and hyperlordosis (23%). Girls had a higher prevalence of spinal deformity (50.65%) compared to boys (49.35%) (p = .029).

The most common deformity was scoliosis. Among students who had scoliosis, 773 (54%) had structural scoliosis and 657 (45.94%) had functional scoliosis. Type of spinal deformity substantially correlated with gender (p = .003), with female students having functional rather than structural scoliosis.

Table 1: The distribution of students in Senior 5 (S5) and Senior 6 (S6) by school (n=5 062), in Rwanda, 2013

Province	District	School	Type and Description	S5[1]	aS6[2]	Subtotal
Northern Province (n =1 552)	Musanze	Groupe Scolaire Kigombe	Day & boarding, private, Seventh Day Adventist, mixed boys 3: girls 1	220	169	389
		Ecole des Sciences de Musanze	Boarding, public, Catholic, sciences. mixed boys 2: girls 1	188	176	364
		ESSA Ruhengeri	Day for boys 5: boarding for girls 1, public.	158	54	212
		Lycee Ruhengeri Apicur	Day and boarding, private, Parents Association	159	179	338
		ES St Vincent Muhoza	Boarding, public, girls only, Catholic, sciences and computer sciences	192	57	249
Southern Province (n=1 565)	Muhanga	Groupe Scolaire Shyogwe	Day & boarding, public, Anglican, Mixed gender	146	146	292
		Ecole Technique de Kabgayi	Day & boarding, private, mixed gender with minority girls, technical subjects	147	111	258
		GroupeScolaire Saint Joseph	Day & boarding, public, Catholic, mixed gender	302	272	574
		ACEJ – Karama	Boarding, private, Parents Association; (subsidixed) separate accommodation	64	61	125
	Ruhango	Groupe Scolaire Byimana	Boarding, public, Catholic 2 boys: 1 girl, science subjects	130	186	316
Kigali Province (n = 1 945)	Nyaruge-nge	College Saint André	Day school, private, Catholic mixed	131	117	248
		Lycée de Kigali	Boarding, mixed gender, public	325	223	548
		APE Rugunga	Day, mixed gender, private, primary & secondary	167	195	362
	Kicukiro	APAPE Gikondo	Day, private, mixed gender	161	173	334
		Lycée de Kicukiro (APADE)	Day, private, Seventh Day Adventist, mix gender	239	214	453
	Total			2729	2333	5062

A significant association was also found between spinal deformity and gender, with females being more prone to deformities than males. There was also significant association between type of spinal deformity and class level (p = .000) with S5 students having more combined deformities.

Table 2: Distribution of Rwandan students' spinal characteristics (n=3 606), 2013.

Description	N	%
Normal spine	1 695	47
Scoliosis only	891	24.71
Hyperkyphosis only	256	7.10
Scoliosis and hyperlordosis	249	6.91
Hyperlordosis only	225	6.24
Scoliosis and hyperkyphosis	162	4.49
Scoliosis, hyperlordosis and hyperkyphosis	128	3.55
Total	**3 606**	**100**

Discussion

In this study, we report on a screening programme for spinal deformities among senior secondary school students in Rwanda. The present sample of 3 606 students compares favourably with those of other screening programmes, for example Japan (n=4 250) (Ugras et al., 2010) and Norway (n= 4 000) (Adobor et al., 2011), but is substantially less than that reported in a large-scale screening study carried out in Japan (n= 250 000) (Ueno et al., 2011). However, the sampling strategy and the sample size were considered sufficient to yield results that allow for generalization to Rwanda as a nation.

Among Rwandan school children, the overall prevalence of spinal deformity (53 %) and scoliosis (39%) was high. International prevalence rates reported in the past years are much lower: 0.87% in Japan (Ueno et al., 2011), 0.5% to 3% in Brazil (Nery et al., 2010), 1.09% in Nepal (Pokharel, Lakhey, Kafle & Shah, 2013), 1 to 2% in Germany (Trobisch, Suess & Schwab, 2010), 11% in South Africa (Stroebel, 2008; Wilders, De Ridder, Ellis & Stroebel, 2009), and 11.8% in the Netherlands (Nery et al., 2010). The results from different studies should be compared with caution, especially since different studies use different methods, such as scoliometry (Pokharel et al., 2013), the Moiré test (Ueno et al., 2011) or a circtometer (Mauriciene & Baciuliene, 2005). Usually, these measures tend to over-estimate spinal deformity. Studies comparing the different methods, including screening diagnosis with radiography where scoliosis is defined as a Cobb angle of larger than 10 degrees (Pokharel et al., 2013), have reported that using clinical measures alone may result in a 20% false-positive scoliosis diagnosis. Whilst most studies focus only on adolescent idiopathic scoliosis, we did not screen for underlying illness. Although the prevalence rate in this study is probably overestimated, the findings emphasize a concern about the occurrence of spinal deformities in Rwandan school children.

Another plausible reason for the comparatively high prevalence of scoliosis in this study is that the participants were markedly older, with a mean age of 19±2.1 years. The possibility exists that we screened students when the accelerated growth spurt of the spine had been mostly complete (Poussa et al., 2005), but this aspect was beyond the scope of the study. Other studies included participants in the pubertal growth period, e.g. 10 to 14 year olds (Ugras et al., 2010) and 11 to 14 year olds (Ueno et al., 2011).

As reported elsewhere (Ellapen & Van Heerden, 2011), female students were significantly more likely to develop deformities than male students across most types of spinal deformities. Reported ratios of girls to boys have included 17:1 (Ueno et al., 2011), 3:1 (Pokharel et al., 2013) and 2.5:1 (Ugras et al., 2010). Our results may be explained in the light of the female development process, where the body changes significantly, e.g. breast and buttock development; which may lead to a change of posture. In Rwanda, girls are culturally discouraged from being involved in sport; girls also tend to be too shy to wear sports clothing. In addition, no structured sport programme was available in the screened schools at the time of this study. Participation in physical activities are known to decline with age among as adolescents, especially in girls (Butt, Weinberg, Breckon & Claytor, 2011; Kimm et al., 2002).

The published literature indicates that other factors influence the development of spinal deformities, such as physical infrastructure (chairs with poor ergonomics), carrying heavy bags and poor posture habits (de Carvalho & Rodacki, 2008; Minoo, Nasser & Mahmood, 2013; Nery et al., 2010). These factors could have contributed to the high prevalence of postural deformities found in this study. Therefore, future studies should examine the role of these factors in order to clarify the present findings.

Based on the findings of the present study, a multidisciplinary health promotion intervention consisting of physiotherapists, occupational therapists, ophthalmologist, audiologists, nutritionists, teachers, school counsellors and school managers particularly those involved in sport, and policy makers targeting school learners could be a viable option for early prevention, as well as rehabilitation of the reported cases.

Limitations and recommendations

The present findings should be interpreted in light of a number of constraints. First, we were unable to use the gold standard for scoliosis detection, i.e. the Cobb angle on radiographs. Second, the Adam's FBT's positive predictive value could vary since it is proportional to the degree of curvature and relies on operator experience (Negrini et al., 2012). However, we employed some strategies to increase the accuracy of the test, but some of these were insufficient. For example, we trained the data collectors prior to doing the field-work, but did not determine inter-tester or intra-tester reliability. In future, the reliability of the test should be evaluated in a local setting.

In this study, we used the subjective FBT to evaluate spinal deformities, which could have contributed to the overestimation of its prevalence. We did not conduct a pilot test, but our research team had experience in doing field work on this scale. We did not account for discrepancies in leg length, which could also influence otherwise normal spinal curvature. Future studies should use scoliometry while sitting to compensate for leg length discrepancy (Grivas et al., 2007). Despite harsh criticism of the Adams FBT (Kim, Tan, Ishikawa & Shinomiya, 2009) the International Scientific Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) recommends that health care providers perform the Adam's FBT test for scoliosis screening purposes, using a scoliometer (Negrini et al., 2012).

Screening for spinal deformities is recommended for children between 8 and 15 years old (Negrini et al., 2012). For this age group it would be important to document the age of onset of menarche in female participants (Kotwicki et al., 2009) in view of its association with changes in hormones such as estrogen (Letellier, Azeddine, Parent, et al., 2008). Therefore, the future screening programmes should take age group into account to ensure that targeted interventions can be done.

Some important risk factors and consequences of spinal deformities could also be assessed in future studies, e.g., severity of deformity, body image and vital capacity, physical infrastructure (chairs with poor ergonomics), carrying heavy bags and poor habitual postures. For research purposes, a specific assessment of trunk asymmetries should be used. Surface measurements (Formetric) of kyphosis/lordosis were proposed (Negrini et al., 2012). One can also consider activity and participation level measures, such as quality of life and aesthetics (Negrini et al., 2012). As the sagittal profile of the spine is frequently modified in scoliosis patients, a sagittal measurement like the plumb-line and the Arcometer is recommended (Negrini et al., 2012).

Scoliosis cannot be prevented. Preventive measures are thus restricted to early diagnosis and timely treatment (Trobisch et al., 2010). "The goal of scoliosis screening is to detect scoliosis at an early stage when deformity is likely to go unnoticed and when there is opportunity for a less invasive method of treatment, or less surgery, than would otherwise be the case. It is recommended that diagnostic evaluation is carried out by clinicians specialized in spinal deformities" (Grivas, Vasiliadis, Savvidou & Triantafyllopoulos, 2008: 759). The same clinicians should be used in longitudinal programmes where possible. Early identification is specifically important as both surgical (Fazal, 2013) and conservative treatment (mainly as out-patient) has been shown to be safe and effective (Weiss, 2010). Specific and personalised exercises are effective especially in cases involving high risk of progression (Negrini, Zaina, Romano, Negrini & Parzini, 2008).

Conclusion

The screened prevalence of the spinal deformities was very high in the studied sample in comparison with those reported in the literature. Health promotion could play an important role in managing the observed spinal deformities and its contributory factors, therefore preventing future cases. The higher screened prevalence of spinal deformity points to the need for a follow-up phase where screen-positive children undergo clinical examination. This may involve confirmation of the diagnosis and rating of severity of the deformity by radiological examination. Spinal screening should be conducted at an earlier age when the spine is still amenable to rehabilitation and when interventions could yield more favorable outcomes than is likely in the studied sample.

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