Making a Difference: Ergonomics for Children in Developing Countries

Kapila Jayaratne
Community Physician, Maternal & Child Morbidity & Mortality Surveillance Unit Family Health Bureau, Ministry of Health, Colombo, Sri Lanka

Introduction:

Children are not smaller versions of adults. Behaviour patterns specific to children pose them at greater risk of environmental hazards than adults. Ergonomics is the science of matching human interaction with the proximate environment. Conventionally ergonomic principles were applied on adult work places to ensure safety of the working environment. With emerging scientific evidence, child environments are being a focus to apply ergonomic principles. The school environment has a strong impact on children's health since they spend much of the daytime within schools during critical developmental stages of their life. Distinct behaviour patterns of children pose them at greater risk of environmental hazards than adults.

Traditional ergonomics focused mainly on adult environments especially in factories, office environments and other work places. Children spend a considerable amount of time during the day in a school environment. One of the crucial parameters of the environment is the ergonomics which plays an important role in influencing the health of school children. Therefore, the school, the “work place” of children is no exception to the introduction of ergonomics.

Evidence pool of ergonomics of children is widening. A multitude of ergonomic hazards have been identified in school settings. The issues include incompatibilities of immediate environmental parameters such as the seating, desk, carriage of school books, position of the blackboard and the surrounding atmosphere (lighting, sounds, vibration and ventilation) with child human factors. Research evidence shows widespread mismatches between student body sizes and desks and chairs. Heavy schoolbag carriage and unhealthy bag behaviour are significant. The negative effects range from general tiredness, musculoskeletal pains, spinal deviations, shoulder level shifts, injuries and even psychological disturbances (Negrini et al. 1999; Harreby et al. 1999; Szpalski et al. 2002; Viry et al. 1999).

School has identified as an effective setting for health promotion. With the introduction of “Health Promoting Schools”, WHO has provided an opportunity to ensure a safe environment for school children (WHO 1996). With a classical ergonomic approach, solutions to health and safety problems in the school environments could be addressed with an understanding of the interaction between children and ergonomic parameters. This will ensure that the school environment is safe for its working population –the children. Success stories are numerous in the integration of ergonomics in school health promotion.

Many initiatives are underway addressing child ergonomic issues. Several industrially developed countries have focused on ergonomics in school environments (Barrero and Hedge 2000; Whittfield et al. 2001; Breithecker D 2005; Heyman and Dekel 2008; Legg and Jacobs 2008; Lueder and Rice 2008). In addition to addressing micro-ergonomics issues such as mismatch between student body sizes and their desks and chairs, the schoolbag carriage and the musculoskeletal disorder prevalence, they are

now focusing on macro-ergonomic issues (Legg and Jacobs 2008). However, a few developing countries have contemplated on addressing even micro-ergonomics issues (Jayaratne, Fernando et al. 2007). Children in industrially developing countries carry a disproportionately heavy share of the environmental disease burden.

Even with the continuing revelations of ergonomic risks and negative health consequences, ergonomic concepts have not yet reached majority of health care professionals and other stakeholders of child health. There is an unmet need of widening the scope of ergonomics as well as health sector (both curative and preventive) contribution to cater for the child ergonomic issues.

Health care professionals and other stakeholders of child health have a crucial role to play with updating their knowledge on ergonomic risks of children and consequences to model clinical management protocols and prevention.

Sri Lanka

Sri Lanka is an industrially-developing country in the Indian sub-continent. Equipped with a stellar combination of scenery, culture and history, a growing focus on sustainable development and a more settled society, Sri Lanka is firmly back on the radar for international attraction. The country profile of Sri Lanka boasts for better health indices on par with industrially-developed countries (Table 1). Key welfare measures adopted in the country are the free health and education systems catering for the entire population.

Table 1: Country Profile – Sri Lanka

Indicator	Value	Unit	Year
Land Area	62,705	Sq.Km	2009
Total Population	20.45	Million	2009
GDP per Capita	2053	US$	2009
Population below Poverty Line	23	%	2006
Literacy Rate	91.3	% >15 Years	2008
Unemployment Rate	5.8	%	2009
Life Expectancy	74.0	Years	2007
Human Development Index	0.759	(Min 0 – Max 1.0)	2007
Maternal Mortality Ratio	31.6	Per 100000 live births	2010
Infant Mortality Rate	9.3	Per 1000 live births	2007
Doctor : Population Ratio	1: 1500		2009

Sources: Central Bank of Sri Lanka and Family Health Bureau

Public concern over schoolbags

There was growing public concern in Sri Lanka over the classroom environments especially on schoolbags –the weight and the behaviour. There were several paper articles appearing on the issue. One article even described carriage of schoolbag by children similar to "an adult carrying a cement bag over the back".

The need

Ergonomic risks in school environments and their impact have not been methodically evaluated in a Sri Lankan context, and not even in the South Asian region. Feasible solutions are available to mitigate ergonomic risks. However, until recently, focus on ergonomic risks to school children was minimal even at international levels. The aim of this study was to provide basic data to promote professional and public awareness of ergonomics related to school children and to apply ergonomics in all educational environments. With the evidence generated or substantiated, formulation of

solutions possible under financial, technical and administrative constraints in school environments could be identified, implemented and evaluated.

OBJECTIVES

The research project was conducted to describe ergonomic factors of the classroom environment and to determine their relationship to musculoskeletal pain and selected physical attributes of school children 11 – 13 years of age with a view to provide ergonomic solutions considering local contexts.

METHODOLOGY

A school-based cross-sectional study was conducted in a representative district of Sri Lanka, Gampaha –a semi-urban district with a population varied in socio-economic, cultural and ethnic characteristics. A wide range of all types of schools according to the classification of schools by the Ministry of Education are available within the same district.

The study process involved;

1. Assessment of distribution of ergonomic and other contributory factors
2. Assessment of musculoskeletal pain prevalence and other consequences of mismatched ergonomics
3. Determination of the association between selected ergonomic factors and consequences of mismatched ergonomics and
4. Formulation of feasible solutions

A sample of 1607 school children was selected from 55 schools using the stratified multi-stage cluster sampling method. Stratification was based on sector, type of school and grade.

An interviewer-guided self-administered questionnaire was used to collect basic information and details on other variables related to ergonomic factors, confounders and negative effects.

Objective evaluation of musculoskeletal pain was overcome by developing and validating the Adolescent Musculoskeletal Pain Assessment Tool or (AMPAT). Tool thus developed showed a satisfactory level of validity and internal consistency.

Distances to the blackboard, measurements of chairs (seat and back-rest), desks, popliteal height and buttock-popliteal length were taken. Height and sitting height of children, body weight, total weight and weights of contents of the bag were measured. Shoulder level shift and lateral deviation of the spine were measured using OSI Scoliometer and Sabia's scoliometer.

The data collection team included trained pre intern medical officers and a number of experienced field-level health care workers. This team was supervised by the principal investigator.

The principal investigator was able to gain hands-on experience on child ergonomics at The International Ergonomic Association – 16th World Congress held in Maastricht, in the Netherlands. This was in addition to the special training that was acquired under an ergonomist in Sri Lanka.

Ethical clearance was obtained from the Ethical Review Committee of the Faculty of Medicine, University of Colombo.

RESULTS

Main findings of the study:

Study Population

The study included 52% male and 48% female students from urban (31.7%) and rural (68.3%) schools belonging to three classification types; 1AB, 1C and 2.

Seating location

The mean of this distance to the blackboard was 398.04 cm with a mean angle 30.71 degrees. A proportion of 76.7% students turned their heads less than 45 degrees while 23.3% had to turn more than 45 degrees to see the centre of the blackboard. In many children (25.5%), seating locations were not changed.

School furniture

A majority (95.6%) of the students sat on a chair with backrest without hand-rests, while 2.1% sat on a common bench. In more than 99% of the students, the seats were made of wood and not cushioned. A back-rest was present in 97.7% seats. Most (52.8%) of the students used the backrest sometimes only.

A higher proportion (78.3%) of the students was provided with an individual desk while 21.7% were given a common desk. Desks of majority (98.1%) of students were made of wood. Desk surface was horizontal in 84.9% and sloped in 15.1% of students. A foot-rest was present in 81.6% desks.

A mismatch of desk / chair combination occurs if the buttock-popliteal length is <80% or >95% of seat depth (Parcells 1999). The buttock-popliteal length of the children was not complying with the seat depth in a total of 87.3% children.

A mismatch of popliteal height and seat height exists if the seat height is either >95% or <88% of the popliteal height. This allows for popliteal clearance of between 5% and 12% of popliteal height (Parcells 1999). A majority (79.8%) of seats did not comply with this requirement.

The legroom height of the desk should be more than the space rendered by popliteal height + 200 mm (Pheasant 1991). Such a mismatch was observed in 1226 (76.3%) desks and chairs provided to the study population.

Carriage of school material

Mean weight of a schoolbag was 3.72 Kg. Mean schoolbag weight as a proportion of body weight was 11.04%. The current internationally recommended cut-off for the weight of the school bag as a percentage of the total body weight is 10%. A bag weighing above the international cut-off was carried by 57.9% of children. Text books accounted for an average of 36.7% of the total weight of the bag, 30.4% other books and 17.7% non-book items. Most (96.9%) students always carried their school bag by themselves. Mean carrying distance of the bag was 3.87 Km while mean carrying time was 24.07 minutes.

Of the backpacks observed 99.4% had movable straps, 91.6% had padded shoulder straps and only 10.4% backpacks were compartmentalized. A waist-belt was present in 29.5% backpacks and of them only 30.5% of students used it. A majority (97.1%) of the students carried the backpack on both shoulders and only 2.9% carried the backpack in other styles.

Negative effects

Seventy two percent of children reported that they perceived at least some level of discomfort having to carry school material.

Sixty two percent students reported a moderate to severe level of general tiredness at the end of school sessions.

The prevalence of recurrent musculoskeletal pain among the study group was highest (35.9%) and acute pain and one-time pain groups showed a prevalence of 19.0% and 16.2% respectively. Nearly 29% of students had no musculoskeletal pain. This meant that a larger proportion (71.2%) of

children reported anytime musculoskeletal pain. Knees, lower back and shoulders are the commonest locations giving rise to musculoskeletal pain in children. A proportion of 63%, nearly two thirds of study population, located pain in more than two anatomical points.

Although, many children reported that it has no effect at all, a significant proportion, more than 50%, reported at least little effect on either school attendance or academic performance.

In the univariate analysis, of the variables considered; female sex, urban sector school, presence of severe general tiredness, abnormal total difficulties score, knowledge of a person with musculoskeletal pain and mismatched seat depth-buttock popliteal length of chair posed a high risk of having recurrent musculoskeletal pain.

Both shoulder backpack carriage, Proper use of waist belt, use of backrest and sleeping on a bed with a mattress lowered the risk of having such pain.

In the regression model, only 09 variables given in the slide were found to be significant correlates of recurrent musculoskeletal pain. Even then one ergonomic factor, mismatched seat depth-buttock popliteal length of chair, posed 1.7 times risk of recurrent musculoskeletal pain.

CONCLUSIONS

With the findings of our study we concluded that;

- Many children did experience discomfort due to sub-standard seating arrangements in the classroom. A significant proportion had to turn their necks to see the blackboard. In many children, seating locations were not changed.
- There is wide-spread incompatibilities of classroom furniture with anthropometric dimensions of children
- A majority of children perceived discomfort due to mismatched classroom furniture
- There were gross deficiencies with regard to carriage of school bags. Deficiencies were noted in weight, model, ergonomic features and the carrying behaviour of bags.
- Children experienced several negative effects, esp. musculoskeletal pain, in part, attributable to mismatched ergonomic factors

Despite the existence of gross deficiencies in ergonomic parameters, it is noted that only few parameters became significant as causing negative effects on children. We must also take into consideration that the capacity of the adolescents to withstand the stresses of an ergonomic mismatch is dependent on a range of other factors in adolescence. These include; differences in musculoskeletal maturation, psychosocial influence of self reporting in this group and influence of extra-academic activities. Ergonomic mismatches were wide spread. Therefore, the students may show a habitual adjustment to furniture size, due to postulated potential reflected compensatory mechanisms, despite the existence of ergonomic incompatibilities.

RESEARCH UTILIZATION

The study revealed the need for major improvements in several ergonomic parameters within the classrooms. We considered it is important to translate research findings into action. Three strategies were adopted; Dissemination of research findings, Provision of feasible solutions and Advocacy

Dissemination of research findings

We shared our research outcomes and recommendations with the Ministry of Education and other relevant stakeholders and had a joint media seminar with them to spread the information to the general public. Several articles were published in print media highlighting the gravity of the issue.

We disseminated the research findings even at international conferences to share and update good practice evidence in an attempt to obtain constructive inputs.

Provision of feasible solutions

Research findings necessitated identification of priority areas and formulation of feasible solutions to improve the current status. As I mentioned early there are about 4 million government school children in nearly 9400 schools. Change of classroom furniture may need substantial financial cost as well as a complex process. Taking into account, several factors including feasibility of implementation and acceptability by the school children and their parents, it was considered that issues related to schoolbags should be a priority area for intervention.

Solutions were contemplated on: strategies for bag-weight reduction, introduction of a model healthy bag and bag behaviour changes.

Strategies for bag weight reduction

In Sri Lanka, the Ministry of Education is responsible for the state sector schools which cater to about 95% of the school going population. There is a well organized administrative structure that facilitates implementation of programs at the school level. Thus, sharing of research outcome and recommendations with the Ministry of Education stimulated considering strategies to lessen the weight of books that have to be carried in the school bag. For example, by splitting the text books in to several volumes and recommending only page-80 writing exercise books.

Introduction of a model schoolbag

The need for modeling a healthy schoolbag was imperative. Inputs were obtained from the International Ergonomic Association and from consultations with experts. Healthy bags designed in other countries were also studied. A healthy schoolbag was modeled by the principal investigator according to ergonomic standards. This sample bag was locally manufactured based on an ergonomically designed healthy bag approved by the Australian Chiropractic Association. Sri Lanka Standards Institute was consulted for physical quality assurance. The sample bag was evaluated by experts, teachers and children. Recommendations were sent to the Ministry of Education.

Implementationof healthy schoolbag campaign

Following successive meetings, several modifications were done. A National Schoolbag Regulatory Committee was established to monitor implementation of healthy schoolbag campaign.

Bag manufacturers were registered by the Ministry of Education and they were educated on the healthy bag concept, ergonomic features, implications of features and technical know how in manufacturing process. Registered manufactureres were requested to make a sample healthy bag to evaluate for quality assurance. Sample bags from bag manufacturers were evaluated by the regulatory committee and bags complied with healthy standards were awarded a ‘healthy bag’ logo certified by Ministry of Education.

National Healthy Schoolbag Initiative was launched at the commencement of the academic year in January 2011 as a joint project of Ministries of Health and Education. Schoolbags in five sizes were introduced to the market by registered bag

manufacturers from all throughout the country. The Secretary of the Ministry of Education issued a circualr with the inputs from health sector.

It specified all the aspects of implementation including; Role of principal, class teacher, parents and children, Healthy schoolbag specifications and Instructions on how to choose and wear the bag.

Behaviour changes

What important is not only the healthy bag with ergonomic features, the correct bag behaviour. Behaviour changes necessitate multiple approaches. Children, Parents and teachers should be made educated using different strategies. A chapter on schoolbag and ergonomic behaviour in the Grade 8 Science Text Book was written by the principal investigator.A leaflet providing information on correct selection, ergonomic features and proper bag behaviour was prepared. It was distributed to all the schools by the Ministry of Education and also it was mandatory to include the same in all the healthy schoolbags approved by the Ministry of Education. Information leaflets in vivid forms were designed and released to the media.

*M*edia explosion

We adopted, what we call, "a media explosion strategy" to disseminate information fast and deep. We utilized both print and also electronic media. Numerous televison programmes, prime time news casts, news paper headlines, articles in women magazines and email communications showed the depth of the penetration of our media strategy. One newspaper article branded the bag "dosthara mahaththayage poth malla" in sinhala to say - Doctor's schoolbag depicting the warmly and the respectful welcome of the new intervention by the general public. It even appeared in cartoons.

Awareness campaigns

Doctors including first contact phsicians, public health workers and peripheral health administrators made aware of the initiative and their role. Information was included in Sri Lanka Medical Association newsletter. Several community awareness campaigns were conducted at educational exhibitions.

Advocacy

Advocacy of policy makers, ministers, administrative officers, health program managers and health care professionals of both health and education sectors, played a crucial role. Both Ministers of Health and Education were updated on the project.

Challenges and the way forward

Naturally, a multi-disciplinary project of this nature would have to face multitutde of challenges.

Commercial

Schoolbag manufacture in Sri Lanka is largely a home-based industry. The schoobag market in the country is being dominated by bag few manufacturing companies who purchases all home-made bags and redistributes throughout the country. Some bag manufacturing companies, without registering or complying with standards, tagged a fake logo in one of their bag models and marketed at a higher price.This was dealt successfully and such companies withdrew the substandard bags.Some "registered" bag manufacturers deliberately raised the prices of their bags implicating that they are of high quality. Few principals of schools negotiated with local registered bag manufacturers for commercial gains which resulted in higher prices of healthy bags. These were highlighted by certain media. Discussions were held with Bag Manufacturers' Associations to rectify the situation.

General public

The education, from the primary to tertiary, is totally free in Sri Lanka. Not only all the text books, even school uniforms are provided by the government to all school children.

With the issue of circular on the implementation of healthy schoolbag by the Ministry of Education, the media with vested interests created a public outcry that government should provide these bags free to all children.

Customer satisfaction

Although the introduced model allows room for diverse outputs of schoolbags. A rigid specification of features of healthybag was not liked by users, school children, as well as producers, bag manufacturers.

There was specific concern over rectangualr shape, which was included to cater for the Ministry of Education's requirement to safeguard free text books from rolling and damaging their edges.

Political

The opposition political parties and trade unions in the education sector, waiting for an issue, tried to capitalize on the issue. One extreme political party issued a statement saying "The government is pick-pocketing Rs. 200/- from each bag bought by the school children". Steps were taken to make the Minister of Education, present Minister of Health and Secretary to the his excellency President to streamline and sustain the project. Positive outcomes achieved.

Professional

There were issues with regard to ownership of the campaign between the two ministries as well as among the personalities involved within the ministries. The writer pioneered the project on his personal interest and not as an official obligation. However with his lead role and commitment, many issues could be settled.

Media

Media played a dual role in the campaign by promoting and penetrating the concept to the general public and also in highlighting the deficiencies. Some media were bias with only highlighting negative aspects. However, with concerted efforts, media are right on track in promoting healthy schoolbag to the nation.

Administrative

The national schoolbag regulatory committe lacked administrative powers. The interest shown by different members were based on their agenda and the stake or the credit they expected to achieve through this project.Discussions are underway to co-ordinate fragmented approaches of Ministry of Education, Ministry of Health and Sri Lanka Standards Institute lead by the speaker. The schoolbag regulatory committee will be strengthened to monitor the implementation of the national healthy schoolbag campaign.Sri Lanka Medical Association, the apex body in the medical profession in Sri Lanka, has already indicated a greenlight to make doctor community aware of "ergonomics" in relevant specialities.

Legal

In addition we are developing a specific standard for schoolbags in consultation with the Sri Lanka Standards Institute. The draft was distributed for public comments and its in the final stage of implementation. Once SLSI standards are in force, it provides a legal framework in manufacturing schoolbags in Sri Lanka.

Financial

There was no specific finances allocated to the project except for the funds received for the research work.The sustainability of a campaign of this magnitude will depend on a strong background of funding. Negotiations are underway with International non-governmental organizations (INGOs) on funding opportunities.

Outcome

We looked at the findings of this study at a 'collective' level in order to plan and implement ergonomic interventions with overall positive effect. Findings of this study and follow up activities highlight that the ergonomic parameters related to classroom could be improved through simple changes. Nearly four million school children will be the beneficiaries of this project. In addition to promoting a healthy school environment for the child, this work attempted to inculcate an ergonomic culture in a country where industrial development is likely to take an important place in the development scenario.

Sri Lanka is seen as a model developing country. Several international mometray agencies are using the Sri Lankan capacity built as South-South

training models (Ref). In such contexts of technology transfer, introduction of ergonomics both at macro and micro levels will undoubtedly contribute to economic and human development.

Recognition

The speaker was invited for the prestigious SLMA Oration *2010*, the highest recognition for medical research, awarded by the Sri Lanka Medical Association.

On the way forward, *m*ost importantly we need to have a continuous focus on awareness programs on healthy schoolbags and proper behaviour changes. The challenge for the future is to improve *all aspects* of the ergonomics in classroom environment for all school children throughout the world. We consider this only as a beginning.

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REFERENCES

1. Barrero, M. and A. Hedge. *School Ergonomics Programs: Guidelines for Parents* 2000 [cited 2009 15 th April]; Available from: http://ergo.human.cornell.edu/MBergo/intro.html.
2. Breithecker D, *More health and well-being in the "school as place of work" -a Project Report*. 2005, Federal Working Group on the Development of Posture and Exercise.
3. Harreby, M, Nygaard, B, Jessen, T, Larsen, E, Storr-Paulsen, A, Lindahl, A, Fisker, I. and Laegaard, E. (1999) Risk factors for low back pain in a cohort of 1389 Danish school children: an epidemiologic study. *European Spine Journal*, 8, 444-450.
4. Heyman, E. and H. Dekel, *Ergonomics for children: an educational program for elementary school.* Work, 2008. **31**(2): p. 253-7.
5. Jayaratne, I.L.K., D.N. Fernando, and J.M.J.S.K. Jayanetti, *Prevalence of musculoskeletal pain and contributory factors among school-going early adolescents*, in *Postgraduate Institute of Medicine*. 2007, University of Colombo: Colombo.
6. Legg, S. and K. Jacobs, *Ergonomics for schools.* Work: A Journal of Prevention, Assessment and Rehabilitation, 2008. **31**(4): p. 489-493.
7. Lueder, R. and V.B. Rice, eds. *Ergonomics for children - Designing products & places for toddlers to teens*. 2008, Taylor & Francis: London & New York.
8. Negrini S, Carabalona R, Sibila P. (1999).Backpack as a daily load for schoolchildren. *Lancet*;354:1974.
9. Parcells C, Stommel M and Hubbard RP. Mismatch of classroom furniture and student body dimensions. *Journal of Adolescent Health*, 1999, 24, 265-273.
10. Pheasant, S. The ergonomics of seating: *Work and Health*. McMillan, London, 1991, pp 212-230
11. Szpalski M, Gunzburg R, Balagué F, Nordin M, Mélot C. (2002). A 2-year prospective longitudinal study on low back pain in primary school children. *European Spine Journal* 11: 459-464.
12. Viry P, Creveuil C, Marcelli C. (1999). Nonspecific back pain in children: a search for associated factors in 14 year old schoolchildren. *Rev Rhum Engl Ed* ;66:381–8.
13. Whittfield, J.K., S.J. Legg, and D.I. Hedderley, *The weight and use of schoolbags in New Zealand secondary schools.* Ergonomics, 2001. **44**(9): p. 819-24.
14. WHO, Promoting Health through Schools: a summary and recommendations of WHO's Expert Committee on Comprehensive School Health Education and Promotion. *WHO Technical Report Series*, 1996, 870, i-vi, 1-93