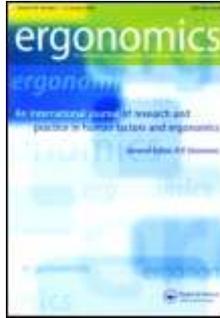


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T. J. Smith. The ergonomics of learning: educational design and learning performance. S. 1530–1546.

The application of ergonomics/human factors (E/HF) principles and practices, and the implementation of ergonomics programmes, have achieved proven success in improving performance, productivity, competitiveness, and safety and health in most occupational sectors. However, the benefits that the application of E/HF science might bring to promoting student learning have yet to be widely recognized. This paper deals with the fundamental purpose of education - student learning - and with the question of how the ergonomic design of the learning environment influences learning performance. The underlying premise, embodied in the quote below, is that student learning performance to a substantial degree is context specific - influenced and specialized in relation to specific design factors in the learning environment. The basic scientific question confronting learning ergonomics is which design characteristics in the learning environment have the greatest influence on variability in learning performance. Practically, the basic challenge is to apply this scientific understanding to ergonomic interventions directed at design improvements of learning environments to benefit learning. This paper expands upon these themes by addressing the origins and scope of learning ergonomics, differing perspectives on the nature of learning, evidence for context specificity in learning and conclusions and research implications regarding an ergonomics perspective on learning.

- **Keywords:** Behavioural cybernetics; Educational ergonomics; Learning ergonomics

A. Woodcock. Ergonomics, education and children: a personal view. S. 1547–1560.

Educational ergonomics - the teaching of ergonomics and the design of environments where ergonomics teaching and learning might occur - has received little attention from ergonomists. This paper first describes the roots of the author's interest and research in educational ergonomics; second it provides a personal view of the opportunities and challenges posed by the two streams of educational ergonomics; and lastly it considers the implications of teaching ergonomics to children in terms of their personal development, the design of schools and the impact such initiatives might have on wider societal problems.

- **Keywords:** Educational ergonomics; Schools

L. Saarni; C. -H. Nygård; A. Kaukiainen; A. Rimpelä. Are the desks and chairs at school appropriate? S. 1561–1570.

The aim of the current study was to find out how the measures of chairs and desks match with the anthropometrics of schoolchildren and how schoolchildren sit during a lesson in their classroom. This paper reports the baseline measurements of an intervention study. Participants of this study were 6th and 8th grade (12 and 14 year old) schoolchildren from two comprehensive schools in Finland ($N = 101$, 57 girls and 44 boys). The main outcome measures were the differences between desk height and elbow-floor height, and chair height and popliteal height. Forty-three participants were randomized for sitting posture analysis by video recordings. The study showed that desks were on average 13 cm above elbow-floor height and chairs 2 cm below popliteal height. For 56% of time participants sat with their backs flexed $>20^\circ$ and/or rotated $>45^\circ$. For 70% of time they sat with their necks flexed $>20^\circ$ or rotated $>45^\circ$. The results indicate that there is a mismatch between school furniture and the anthropometrics of schoolchildren. Schoolchildren sit in disadvantaged postures for a substantial part of school lessons.

- **Keywords:** Schoolchildren; Anthropometrics; Sitting posture; Desk; Chair

E. Geldhof; D. De Clercq; I. De Bourdeaudhuij; G. Cardon. Classroom postures of 8-12 year old children. S. 1571–1581.

This study examined classroom postures of 8-12 year old school children in Flanders and related the outcomes to self-reported back or neck pain. Postural behaviours using the portable ergonomic observation (PEO) method and self-reported one-week back and neck pain were studied in 105 children from 41 different class groups. Pupils sat statically for 85% of the time, 28% of which the trunk was bent or flexed forward. For 9% of the time, children sat dynamically and for 36% they used a back rest. Children who spent more time sitting with a flexed trunk reported significantly more thoraco-lumbar pain compared to pain-free children and to children with cervical pain ($p < 0.05$). Children reporting pain stood for a longer period of time than pain-free children ($p < 0.05$). It is concluded that prolonged static kyphotic sitting without use of a backrest is common in elementary school children in Flanders.

- **Keywords:** Sitting posture; Schoolchildren; Ergonomics observation

R. Breen; S. Pyper; Y. Rusk; S. Dockrell. An investigation of children's posture and discomfort during computer use. S. 1582–1592.

This study investigated schoolchildren's posture and discomfort while working at computers. Sixty-eight children (mean age 9.5 years) were observed at school during normal computer sessions lasting 15-25 min. Rapid upper limb assessment (RULA) was used to evaluate posture, and a body discomfort chart (BDC) and a modified visual analogue scale (VAS) were used to record site and intensity of discomfort. Computer tasks were noted and in accordance with RULA, postures were classified as Action Level (AL) 1 (acceptable) to 4 (needs immediate change). Most children adopted postures at an unacceptable level while working at computers. None of the postures were in AL 1; 60% were in AL 2; 38% were in AL 3; and 2% were in AL 4. Posture became worse over time. Poor posture was associated with discomfort, but it is not clear if it was related to the sitting posture or to the computer use. Children who reported discomfort had a higher mean RULA grand score (5.0) than those who did not report discomfort (4.4). The type of computer task influenced the children's posture. RULA proved generally to be a suitable method for evaluating children's posture.

- **Keywords:** Children; Posture; Discomfort; Computers

N. Tuttle; R. Barrett; E. Gass. Seated buttock contours: a pilot study of Australian senior high-school students. S. 1593–1602.

Both posture and comfort of a chair are influenced by the contour and characteristics of the seat. Knowledge of seat contours of a student population could thus be useful in the design of school chairs. This study investigated seated buttock contours of senior high-school students in order to determine: (a) their general characteristics, (b) the effect of gender and sitting posture and (c) the relationship between the contours and selected anthropometric variables (stature and mass). A contour measurement device was developed and used to measure buttock contours in five sitting postures (typing, sitting up, sitting back, slumping and writing). Buttock contours were quantified by constructing anterior-posterior (AP) and lateral profiles from which six discrete profile dimension measurements were made. AP and lateral profiles were found to have a consistent shape across all participants. Five out of six profile dimensions were significantly different between genders, with just one significantly different between sitting postures (typing and sitting back). Correlations between anthropometric measures and profile dimensions were relatively low ($r < 0.34$) with no clear patterns evident. Overall results of this study suggest that buttock contours are influenced by gender to a greater extent than sitting posture.

- **Keywords:** School chair design; Seat contour

N. Tuttle; R. Barrett; E. Gass. Preferred seat orientation of senior high-school students. S. 1603–1611.

The height of the front of the seat is the primary determinant of appropriate seat size in the school setting. In the present study, this dimension was fixed at 445 mm and, using a brief adjustment period, students adjusted the angle of the seat to their preferred rear seat height (PRSH) under three fixed and one adjustable desk height conditions and for one desk height, under two time conditions. PRSH was significantly greater at an 800 mm desk height (454 ± 14 mm) compared to 735 mm (447 ± 15 mm) and 720 mm (444 ± 16 mm). When desk height as well as rear seat height were adjustable, PRSH was 446 ± 15 mm and preferred desk height 751 ± 25 mm. Taller students or those with larger popliteal heights selected lower PRSHs at all desk heights, with PRSH more strongly related to popliteal height ($r = -0.54$ to -0.59) than stature ($r = -0.44$ to -0.50). No differences were found in PRSH between short (<5 min) and long (30 min) adjustment periods for the 735 mm desk height. The nearly horizontal seat positions found in this study were between those recommended by other authors.

- **Keywords:** School chairs; School furniture

C. S. Savanur; C. R. Altekar; A. De. Lack of conformity between Indian classroom furniture and student dimensions: proposed future seat/table dimensions. S. 1612–1625.

Children spend one-quarter of a day in school. Of this, 60-80% of time is spent in the classroom. Classroom features, such as workspace and personal space play an important role in children's growth and performance as this age marks the period of anatomical, physiological and psychological developments. Since the classroom is an influential part of a student's life the present study focused on classroom furniture in relation to students' workspace and personal space requirements and standards and was conducted in five schools at Mumbai, India. Dimensions of 104 items of furniture (chairs and desks) were measured as were 42 anthropometric dimensions of 225 students from grade six to grade nine (age: 10-14 years). Questionnaire responses of 292 students regarding the perceived adequacy of their classroom furniture were collected. Results indicated that the seat and desk heights (450 mm, 757 mm respectively) were higher than the comparable students' anthropometric dimensions and that of the recommendations of Bureau of

Indian Standards (BIS) (340 + 3 mm, 380 + 3 mm seat-heights, 580 + 3 mm 640 + 3 mm desk-heights) as well as Time-Saver Standards (TSS) (381.0 mm seat-height and 660.4 mm desk-height). The depth of the seats and the desks (299 mm, 319 mm, respectively) were less than comparable students' anthropometric dimensions and the recommendations of BIS (IS 4837: 1990). Students reported discomfort in shoulder, wrist, knee and ankle regions. Based on the students' anthropometric data, proposed future designs with fixed table-heights and adjustable seat-heights along with footrests were identified.

- **Keywords:** Classroom; Furniture; Anthropometry; Standards

G. García-Acosta; K. Lange-Morales. Definition of sizes for the design of school furniture for Bogotá schools based on anthropometric criteria. S. 1626–1642.

The current paper deals with the definition of sizes for the design of school furniture for schools in Bogotá, Colombia, based on an analysis of available anthropometric data on Latin American children. State-of-the-art anthropometric, national and international standards were considered, in order to define the anthropometric variables that were to be used for defining the furniture. Matrices relating age and specific anthropometric dimensions were constructed, as a visualization method for establishing the dimensional differences between children of the same age and the ranges that should be covered by the items of furniture. Dimensional data were grouped by establishing the minimum sizes and general dimensions of furniture needed to cover the 5-95th percentile of school children between the ages of 5 and 18 years. The distribution of the furniture in the different school grades was also indicated. Apart from the need for an adequate match between child anthropometry and school furniture dimensions, this study shows the importance of a proper distribution of furniture sizes in the different school grades, as a complementary and decisive aspect to be considered in order to meet the heterogenic, anthropometrical requirements of children of the same age and school grade.

- **Keywords:** School furniture design; Anthropometry of Latin-American children; Visualization matrices; Definition of sizes; Distribution of sizes

R. Koskelo; K. Vuorikari; O. Hänninen. Sitting and standing postures are corrected by adjustable furniture with lowered muscle tension in high-school students. S. 1643–1656.

This study compared the effect of 24 months of adjustable school desks and chairs usage (the intervention) and traditional non-adjustable usage (the control condition) on sitting and standing postures, muscle strength, classroom muscle tension, pain and learning in 15 (8 female and 7 male) high-school students and 15 anthropometrically and gender matched control students from neighbouring schools. It was assessed whether any responses took place after growth cessation. In comparison with controls, the intervention group of students' sitting postures standing kyphosis, scoliosis and lordosis became significantly better, both before and after growth cessation. Trunk muscle strength increased in the intervention students whose muscle tension during classes fell significantly in the trapezius and lumbar muscles, whereas in control students' lumbar tension increased. Headache and low-back pain correlated with neck-shoulder pain and trapezius muscle tension. Intervention students reported that they experienced benefits from the adjustable tables and chairs. They also received significantly better overall marks than the controls at the end of high school. It is concluded that the adjustable school desks and chairs promoted better sitting and standing postures, increased muscle strength, alleviated pain and appeared to be associated with better overall academic marks.

- **Keywords:** Adjustable school desks; Student growth; Standing and sitting postures; Muscle strength

S. Dockrell; E. Fallon; M. Kelly; B. Masterson; N. Shields. School children's use of computers and teachers' education in computer ergonomics. S. 1657 – 1667.

A national survey to investigate the education of teachers in computer-related ergonomics was carried out by postal questionnaire. The use of computers by primary school children (age 4-12 years) was also investigated. Data were collected from a random sample of 25% ($n = 830$) of primary schools in the Republic of Ireland. Questionnaires ($n = 1863$) were returned from 416 schools giving a response rate of 50.1%. Almost all schools (99.7%) had computers for children's use. The computers were most often (69.8%) used in the classroom. The majority (56.3%) of children worked in pairs. Most teachers (89.6%) had received computer training, but few (17.6%) had received ergonomics information during the training. Respondents were not satisfied with their current knowledge of ergonomics. Over 90% stated that they would like to receive further information by printed format or during a training course, rather than by computer (web or CD-ROM).

- **Keywords:** School children; Computer ergonomics; Teacher education

H. W. Mackie; S. J. Legg. Measurement of the temporal patterns of school bag carriage using activity monitoring and structured interview. S. 1668–1679.

The primary objective of the current study was to quantify the temporal patterns of school bag carriage over an actual school day using activity monitoring and structured interviews, in order to better understand the physical demands of school bag carriage. The temporal patterns of 40 students' school bag carriage over a 24-h period were defined by total school bag carrying time, mean event school bag carrying time, the number of school bag carrying events, total carrying time travelling to and from school and the number of students who walked or used transport to travel to and from school. There were significant correlations between activity monitor [mean(SD) 119(48) min] and structured interview [100(39) min] determined total school bag carrying time ($r = 0.59$), activity monitor [8(4) min] and structured interview [9(4) min] determined mean event school bag carriage time ($r = 0.65$), and activity monitor [15(4) events] and structured interview [11(2) events] determined number of school bag carrying events ($r = 0.52$). However, the number of school bag carrying events, and for students who used transport, the total amount of time spent travelling to school was significantly different using the two measures. The durations of school bag carriage and the relationship between activity monitor and structured interview were similar to those reported in previous studies.

- **Keywords:** School; Load carriage; Time; Activity monitor

M. A. Jones; G. Stratton; T. Reilly; V. B. Unnithan. Recurrent non-specific low-back pain in adolescents: the role of exercise. S. 1680–1688.

This study evaluated the efficacy of an exercise programme as an intervention for recurrent non-specific low-back pain (NSLBP) in adolescents. A randomized controlled trial was conducted with an experimental group ($n = 27$, age 14.6 years) who participated in an 8-week exercise programme and a matched control group ($n = 27$, age 14.6 years) who continued normal daily activities. All participants suffered from recurrent NSLBP. Pre and post intervention measures of NSLBP status (pain severity and consequences) and daily inactivity (time spent sitting, PC time, TV time) were reported in one week diaries. Two-way mixed ANOVA (independent variables: pre/post and experimental/control) was conducted for each dependent variable, significance was set at $P < 0.05$. Significant interaction effects were identified for the severity of pain, number of occasions missing sport due to NSLBP and amount of sport participated in. In each case the experimental group benefited from the exercise programme. In contrast, no significant interaction effects were observed for physical inactivity, both groups spent a

similar amount of time sitting, watching TV and using a PC pre- and post- intervention. It was concluded that an exercise programme acted as an effective short-term treatment strategy for NSLBP in adolescents. Further evaluation is required to assess the long-term effectiveness.

- **Keywords:** Adolescents; Low-back pain; Exercise programme

G. Havenith. Metabolic rate and clothing insulation data of children and adolescents during various school activities. S. 1689–1701.

Data on metabolic rates ($n = 81$) and clothing insulation ($n = 96$) of school children and adolescents (A, primary school: age 9-10; B, primary school: age 10-11 year; C, junior vocational (technical) education: age 13-16 (lower level); D, same as C but at advanced level; and E, senior vocational (technical) education, advanced level: age 16-18) were collected (Diaferometer, Oxylog, Heart Rate derivation) during theory-, practical- and physical education- lessons. Clothing insulation was calculated from clothing weight, covered body surface area, and the number of clothing layers worn. Clothing insulation was found to be similar to that expected for adults in the same (winter) season, with minimal variation with age or school type (0.9 to 1.0 clo; 1.38 clo where coverall was worn), but more variation within groups (coefficient of variation 6-12%). Metabolic rate values ($W.m^{-2}$) were lower than expected from adult data for similar activities, but are supported by other child data. The results of this study can be used to establish design criteria for school climate control systems or as general data on energy expenditure for children and adolescents. The results emphasize the need for specific child data and show the limited value of size-corrected adult data for use in children.

- **Keywords:** Energy expenditure; Metabolism; Children; Oxygen uptake; School, clothing insulation; Climate assessment

F. Guercin. Road-safety education: spatial decentering and subjective or objective picture processing. S. 1702–1712.

The current study examined children's ability to analyse pictures of a risky situation, both in relation to the characteristics of the pictures and in relation to the centering/decentering process of cognitive development. Sixty children aged 6, 9 or 11 years were given an objective or subjective version of a story about a risky situation involving road crossing and were asked to reconstruct it by putting six pictures in chronological order. The type of picture series, objective or subjective, had a different effect on the children's understanding and performance, according to the age. The older children were better at ordering the pictures, but on the subjective version only. The picture-version effect on planning time decreased with age; only the younger children took more time to start touching the pictures. On one hand, it is concluded that for the youngest children, objective representations are essential to analysing pictures showing a risk, whereas the oldest children will profit more from a subjective view. On the other hand, subjective representations, which give a more realistic view, provide an excellent tool for testing children's abilities. Subjective representations can be used to detect potentially risky behaviour in virtual situations (static pictures, or multimedia tools), since it permits one to predict at-risk behaviour in the street and to assess the effectiveness of remedial measures.

- **Keywords:** Learning from pictures; Child pedestrian education; Decentering; Cognitive development; Picture integration