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Evaluation of Two Ergonomics Intervention Programs in Reducing Ergonomic Risk Factors of Musculoskeletal Disorder among School Children

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Abstract: An intervention study was done from February 2009 until August 2009 with the objective of investigating the effectiveness of two ergonomics intervention programs in reducing ergonomic risk factors among 229 school children in 2nd Grade (age 8 years) and 5th Grade (age 11 years) in three schools. Group 1 (G1) assigned to one school, which implemented the ergonomically design furniture in their class (among 2nd and 5th grade students), Group 2 (G2) from other school implemented ergonomics program with intensive health promotion toward ergonomic awareness consisted with exercising and education to reduce MSD, while Group 3 from another school selected as Control Group (Cx). Musculoskeletal symptoms were recorded using modified nordiq body map questionnaires. Modified Rapid Upper Limb Assessment (RULA) was used to assess the awkward posture of the school children. Ergonomic awareness test performed namely Ergonomic Quiz (EQ) to evaluate the awareness level before and after ergonomic intervention programs. Tanita weight measurement was used to measure school bag weight and students' weight. Weight of the bag, RULA score and EQ were used as main indicator to analyze the effectiveness of programs to reduce ergonomic risks. A significant reduction of RULA score among sub-sample students and mean bag weight observed among G1<G2 and Cx indicate the ergonomic risk were reduce accordingly. Higher EQ score recorded among G1 students compared to G2 and Cx but the result were insignificant. The implementation of ergonomically design furniture in classroom able to reduce risk and reported MSD symptoms.

Key words: School children, Musculoskeletal Disorder (MSD), Rapid Upper Limb Assessment (RULA), ergonomic intervention programs, bag weight, ergonomic quiz

INTRODUCTION

Ergonomics is a science that seeks to comfort the workstation and all of its physiological aspects to the human (David and Geotsch, 2008). In Malaysia, almost every child had undergone school education every day except on weekends and public holidays. However, the school is not a safe environment for them as they could become injured or sick, which can all be attributed to school. In Malaysia, ergonomics issues among school children are not documented widely compare to other issues such as air pollution, water pollution and other hazards in school (Syazwan *et al*., 2009). Workstations at school are among several factors that may contribute to musculoskeletal pain among school-aged children. During lessons in the classroom, children often sit in poor postures with trunk, back and neck flexed or rotated even for longer periods of time (Murphy and Buckle, 2000; Murphy *et al*., 2004. School children in the classroom have, to a large extent, been excluded from ergonomics applications designed to prevent musculoskeletal problems (Steven *et al*., 1994).

Generally in most school environments, many factor can influence student's sitting posture, this include the anthropometric dimensions of school children, the measurement specifications and design features of school furniture (Yeats, 1997). School-aged children, for example may spend about 30% of their class working hours at school, much of it sitting posture (Syazwan *et al*., 2009). When posture of the students were compromise with awkward body position, when sitting adding with the heavy lifting of school bag can introduce harm and danger to the student musculoskeletal system (Murphy *et al*., 2004). Population-based studies have demonstrated that the lifetime prevalence of musculoskeletal disorder in children and adolescents varies between 7 and 63% (Jones *et al*., 2003). Wedderkopp *et al*. (2001) suggested that the spine

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should be considered as three distinct entities (neck pain, upper back pain and low back pain) as thoracic pain is more common in younger children. Ergonomics awareness in school environment have not being implemented seriously in Malaysia and as the result most of the children poses greater risk to ergonomic hazard due to the heavy lifting of school bag and incorrect sitting posture in classrooms that can lead to develop musculoskeletal pain at any body part in the future (Syazwan *et al*., 2009).

Today's furniture design in developing country does not consider proper ergonomic sitting and comfort issues. In school settings, Mandal (1982) had proposed the use of desks with slanted tops and specially designed chairs with curved seats, which should promote proper sitting. The chairs are meant to provide proper back posture if the child is listening (sitting against backrest) or perform class work (sitting forward towards slanting desk). Intention to adopt healthy behaviors, like any other type of behaviors, is motivated or triggered by stimuli in an individual's environment (Egger, 2004). Many factors can increase the risk on developing musculoskeletal disorder after expose to constant ergonomic hazard such as awkward posture in sitting position. For the school children, they are small group size of people and need special chair design for them to sit for a long period of time without experience any back injury (Yanto *et al*., 2008). In study conducted by Yanto *et al*. (2008) mismatched occur among the school children where their furniture in class cannot meet with their body dimension and lead to an increase complain result to buttock and back pain.

The purpose of the present investigation was to study the effects of the implementation of ergonomically designed desks and chairs for pupils in an applied setting from previous study conducted by Nurul *et al*. (2009) and compare with the others intensive health promotion program towards ergonomic awareness. Specifically, we were interested in how this ergonomically designed furniture would be received in the classroom and whether it would result in altered sitting posture, beg weight load status reduction between each group in this intervention study.

MATERIALS AND METHODS

Study design and location: This study was funded by University Putra Malaysia (Research University Grant Scheme) Vote No. 91128 (sponsoring information). An intervention study design was employed, in which Group 1 (G1) receiving ergonomically designed desks and chair in intervention program with a brief explanation regarding the proper usage of the furniture (Fig. 1). Group 2 received intensive health promotion towards ergonomic issues with current existing furniture. Group 3 (Cx) was being recruited to become the control group as compared to others ergonomic intervention programs. The current existing furniture consisted of a desk with a flat top (parallel to the floor) and a chair with a straight back and seat placed at a 90°. The furniture was used during a 6 month period and assessments were made before and after the intervention as well as two 1 month follow-up.

Fig. 1: Ergonomically design furniture (chair on the left and desk on the right among G1

Participants and subject recruiting: Six classes consisted of 3 class of 2nd grade and 3 class of 5th grade from all three schools were invited to participate in the study. Two classes contained 2nd and 5th grades of one school were randomly assigned to become experimental group by using ergonomically design desk and chair ($n = 76$) and marked as G1. Then, 2 classes (2nd and 5th grade) in other school randomly selected to be served as G2, which using current existing furniture with health promotion program about ergonomics issues ($n = 78$). Two other classes (2nd and 5th grade) were randomly assigned from another school served as a control group ($n = 75$). These groups were very similar with regard to socioeconomic background, age (G1, G2 and Cx for 2nd grade = 8 years, 5th grade = 11 years old) ($p>0.05$).

Data base collection: In early stage of the study, all students from G1, G2 and Cx were given a set of modified Nordiq Body Map Questionnaire (NBMQ) to record the musculoskeletal pain among the schools children (Kuorinka *et al*., 1987). The NBMQ questionnaire showed a body map diagram of 9 body parts divided into neck, shoulder, upper back, lower back, elbow, arm, hand, thigh, knee and leg so to assist the students in identifying the correct body parts in answering the questions. An Ergonomic Quiz (EQ) was also conducted to evaluate the knowledge about ergonomic hazard. Questions on knowledge of MSD risk factors such as do you know how to seat on your chair? (A = yes, B = no) closed ended question that need to be choose and write on the Optical Mark Recognition (OMR) answer sheet. The OMR answer sheets were given among G2 and G3. Each correct answer was given a score of 1. School bag weight was measured during the baseline data collection for all study subjects using Tanita weight measurement. Assessment of Rapid Upper Limb Assessment (RULA) then performed using modified RULA assessment worksheet without acknowledging the students to avoid healthy student effect. The RULA observation assessments were conducted among G1 in the implementation of ergonomic furniture commissioning.

Development of ergonomic intervention program for G1, G2 and Cx: Two type of intervention programs were performed during the study. The G1 receive a set of ergonomically design chair and desk for each grade (2nd and 5th) as showed in Fig. 1. The intervention program for G1 was firstly developed using the information collected during the 1st phase and also based on literatures (Syazwan *et al*., 2009). The desk and chair that had been given to the students were constructed using anthropometric database collection from previous study (Nurul *et al*., 2009). The ergonomically design desk had been equipped with personal drawer for school children to store their excess book at school without carrying it in the schoolbag. The researcher then demonstrates to the G1 students on the correct method in using the furniture given during practical session with all students.

In another school, which had similar coeducational characteristic assigned as G2 and received a package of health promotion program consists of poster, pamphlet, flyers and also Video Compact Disc (VCD) documentary about ergonomic issues and method in reducing ergonomic risk factors by applying several short exercise in 5 min each (Fig. 2). The intervention program for G2 was firstly developed using the information collected during the data baseline collection and based on identified risk factors. The curriculum of the VCD documentary developed include) prevalence of MSD among school children) risk factors of MSD) adaptation of optimal ergonomics seating posture) exercise and stretching (in the morning, when seating in the chair and during resting time at school) with each exercise requiring 10-16 repetitions and 5) correct lifting techniques. Using the guidelines, the researchers developed a detailed storyboard that includes film, graphic or animation, screen title and narration. The pamphlet, demonstration and video presentation were based on the storyboard so that the contents remained the same for all package. A demonstrator was recruited by the researchers to guide

Fig. 2: Ergonomic intervention using health promotion to reduce ergonomic risk among G2

Fig. 3: Other health promotion on dengue prevention among control group

the participants the correct method of exercise as shown in the video. The intervention program was done in the native Malay language. Control group was given a different package of health promotion consisting of the same material as G2 except the content had been modified to another health promotion on dengue control (Fig. 3). Two intervention programs were conducted to each group (G1, G2 and Cx) at interval of two months, respectively.

Assessment conducted to measures risk changes: After data collection process, the two intervention period (INT1 and T2) were performed. In the intervention session, G1 were given set of ergonomically furniture with instruction of using the furniture by researcher. For G2 intervention program, the researcher conducted a session of health promotion to educate the students on reducing the ergonomic risk by adapting the existing furniture by good body posture and exercising. In Cx, other health promotions were introduced to replace the package compared to G2. The intervention one (INT1) were conducted one month after the database collection ended. One month after the INT1, Assessment one (ASS1) were performed to measure indicators namely (Ergonomic quiz score) RULA score and) Schoolbag weight. Evaluations consisted of Ergonomic Quiz (EQ) was conducted among the study groups (G1, G2 and Cx) in the assessment period. A set of Ergonomic Quiz (EQ) regarding MSD and its associate factor was distributed among both groups (intervention and control groups) to assess the knowledge of ergonomic issues.

Then a set of NBMQ also distributed to record MSD complain. Third item in assessment one include the behavioral observation of the study subject performed using modified Rapid Upper Limb Assessment (RULA) (Syazwan *et al*., 2009). All study groups were assessed by RULA checklist to identify the awkward posture performed in classroom environment. Systematic random sampling was employed in selecting the student in each class, when RULA was performed in each class (Syazwan *et al*., 2009). For RULA observation in ASS1, the selected children were observed individually in the classroom at one assessment periods for average 2 h in overall class session. Then same procedure for ASS2 was done, where the observation was made and score was given. After one month of ASS1, intervention two (INT2) were performed by researcher with the same tools as mentioned in INT1. After INT2, same assessment as ASS1 was performed to measure the same indicator in assessment two (ASS2) one month after the INT2. In the stage of assessment, a set of modified Nordiq Body Map Questionnaire (NBMQ) was used to record the musculoskeletal pain complain among school children were given.

Rapid Upper Limb Assessment (RULA): The posture analysis among student was performed using Rapid Upper Limb Assessment (RULA) (McAtamney and Corlett, 1993). Posture of the student in this study was assessed and good inter reliability result were obtained (α Cronbach = 0.8120, 0.7951, 0.7851, 0.8141, 0.8310, 0.7931 for arm analysis, wrist, neck, trunk, leg and muscle, respectively). Modified RULA were recorded as numerical scores and the score was then translated using specific RULA matrix of scoring whereby a high grand score indicate a severe awkward posture.

Validity: The effect of test wise was eliminated by performing a sequence of INT1 and INT2 of 1 month duration. The instrumentation factor was maintained by having the same instructor and demonstrator for the whole intervention and assessment programs. Randomization of group selection was able to control differential selection effects and selection maturation interaction effects.

Quality control and ethical issues: Pre-test questionnaires was performed on 10% of sample size before the start of the study on school children aged 8 and 11 years old to ensure the understanding of the questions (face validity). In order to control the selection bias, matching one to one procedure among group (G1, G2 and Cx) were conducted controlling for) the mode of transportation of the school children to school), the distance of the school) the school bag type and iv) the method of carrying school bag daily. Approval from Medical Researcher Ethic Committee, UPM was obtained. Written consent from the parents/guardians of the school children were obtained before data collection. Reference item of Ethical Approval was (UPM/FPSK/PADS/T7-MJKEtikaPer/F01_(JKK_AIR (09) 01).

RESULTS AND DISCUSSION

Demographic information of respondents is shown in Table 1. Modified RULA assessment for school children showed there were significant different in RULA score between two groups with the higher scores among 2nd grade compared to 5th grade students (Table 1). The study showed that from the 9 body parts, the lifetime prevalence of MSD showed that the highest complain was shoulder pain (16.4%) among the 2nd grade children and neck pain (38.0%) was the highest complained among the 5th grade. The overall prevalence MSD shows that the 5th grade reported the higher complaint (67.0%) than the 2nd grade (36.0%) (Table 2).

The study showed that G1 and G2 showed significant increase of EQ scores for both grade (2nd and 5th) from Baseline to ASS1 as shown in Table 3. However, in the ASS2, G1 and G2 showed significant reduction of EQ for both grade (2nd and 5th) except G1 of 2nd grade, which shows a low EQ score between ASS1 and ASS2 (Fig. 4) ($p>0.05$).

For RULA observation, the study shows that G1 and G2 had significant reduction of RULA score among all respondents in ASS1 and ASS2 (Table 3 and Fig. 5). Group 1 showed the lower reduction of RULA score compare to G2 group. Result showed that G1 significantly reduce the mean of bag weight among both group (2nd and 5th grade) in ASS1 and ASS2 (Table 4 and Fig. 6). Group 2 showed significantly reduce bag weight only among 5th grade students in ASS1. This study was conducted to evaluate two ergonomic interventions in

Table 1: Demographic information among 229 school children in baseline data collection

Variables	Frequency	Percentage
Grade		
2nd	110	48.0
5th	119	52.0
Gender		
Male	94	41.0
Female	135	59.0
Race		
Malay	197	86.0
Indian	22	9.6
Chinese	2	0.9
Others	8	3.5
Transportation		
Bus/Car	214	93.4
Walk	15	6.6
Time for travel		
<15 min	187	81.7
>15 min	42	18.3
Home activities[a]		
Yes	154	67.2
No	75	32.8
Comfort of chair		
Yes	171	74.7
No	58	25.3
Comfort of desk		
Yes	184	80.3
No	45	19.7

Variables	2nd grade (n = 110)	5th grade (n = 119)	t-value	p-value
Anthropometric				
Weight	23.61±6.20	35.54±10.30	-10.524	<0.001*
Height	122.10±6.71	132.14±12.51	-7.453	<0.001*
BMI	15.63±2.55	20.52±6.00	-7.912	<0.001*
Bag weight	4.63±1.03	4.89±1.43	-1.606	0.110
	(n = 56)	(n = 61)		
RULA score[b]	5.35±0.47	4.94±0.64	3.901	<0.001*

[a]Use Personal Computer at home (PC) and watch TV, [b]The RULA score conducted for sub sample of each class, *Significant at p<0.05

Table 2: Lifetime prevalence (%) and 7 days prevalence (%) of body part complaint among school children

	Life time			7 days		
Body parts	2nd grade (n = 110)	5th grade (n = 119)	All	2nd grade (n = 110)	5th grade (n = 119)	All
Neck	14.5	37.8	61	8.2	22.7	36
Shoulder	16.4	31.9	56	9.1	16.8	30
Elbow	11.8	3.4	17	7.3	2.5	11
Arm	10.9	17.6	33	5.5	5.0	12
Upper back	8.2	17.6	30	3.6	6.7	12
Lower back	6.4	18.5	29	1.8	8.4	12
Hip and thigh	6.4	19.3	30	4.5	10.1	17
Knee	8.2	14.3	26	6.4	5.0	13
Leg	12.7	19.3	37	7.3	8.4	18
MSD experience in lifetime	36.4	67.2	120	24.7	47.9	84
MSD prevalence (1 month)						
Yes (%)	41 (37.3)	87 (73.1)	128			
No (%)	69 (62.7)	32 (26.9)	101			
Injured during physical education class						
Yes (%)	18 (16.4)	56 (47.1)	74			
No (%)	92 (83.6)	63 (52.9)	155			

three schools to determine, which programs can reduce ergonomic risk among school children. In addition, this study also determines the prevalence of MSD amongst schoolchildren and the role of physical factors in association with subsequent symptomology were made. The primary aim of the study was to estimate the risk reduction of ergonomic intervention programs with the different approach. Dominant pain location for lifetime prevalence recorded for 5th grade was the neck (37.8%) followed by the shoulder (31.9%) and thigh (19.3%).

Table 3: Comparison of Ergonomic Quiz scores and RULA scores for 2nd and 5th grade from three groups

Variables	2nd grade Group 1	Group 2	Group 3	F		5th grade Group 1	Group 2		F	
	(n = 37)	(n = 38)	Cx (n = 35)	(ANOVA)	Sig.	(n = 39)	(n = 40)	Cx (n = 40)	(ANOVA)	Sig.
Ergonomic quiz score										
Baseline ergonomic quiz[a]	53.85±8.94	53.58±7.32	52.22±10.64	0.333	0.717*	50.53±11.28	53.27±7.08	52.15±7.24	0.980	0.378
ASS1 ergonomic quiz[a]	83.27±10.87	62.66±11.90	50.84±9.24	84.189	<0.001	86.99±12.42	73.07±9.40	54.00±8.06	106.225	<0.001
ASS 2 ergonomic quiz[a]	80.33±14.69	68.23±11.17	54.99±12.32	34.79	<0.001	83.70±8.08	78.96±9.40	54.72±10.44	109.46	<0.001
	2nd grade					5th grade				
Variables	Group 1 (n = 19)	Group 2 (n = 19)	Group 3 Cx (n = 18)	F (ANOVA)	Sig.	Group 1 (n = 19)	Group 2 (n = 20)	Cx (n = 22)	F (ANOVA)	Sig.
RULA observation										
Baseline RULA[b]	4.63±0.43^	5.28±0.43	5.50±0.50	19.42	p<0.001	4.63±0.60^	5.45±0.59	5.35±0.33	14.22	p<0.001*
ASS1 RULA[b]	3.63±0.33	4.14±0.55	5.78±0.56	98.25	p<0.001	3.50±0.43	4.15±0.48	6.19±0.34	215.94	p<0.001
ASS 2 RULA[b]	2.73±0.33	3.09±0.47	6.07±0.41	378.37	p<0.001	2.71±0.31	3.15±0.49	6.39±0.44	445.50	p<0.001

[a]Total mark for the ergonomic quiz is 53 (full mark), *p value a cross are comparing mean between G1, G2 and Cx, ^Baseline RULA observation taken immediately after installation of ergonomic furniture among G1, [b]Sub sample was performed by systematic random sampling for each group and grade, Cx is a control group. Values are expressed as mean±SD

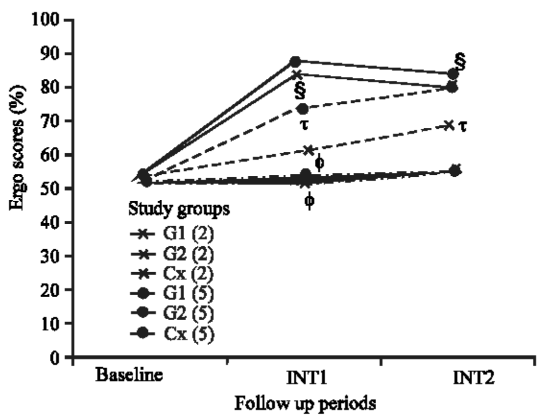

Fig. 4: Repeated GLM of ergonomic quiz among 2nd and 5th grade, §Ergonomics quiz assessment for G1 from Baseline to ASS1 until ASS2 (p<0.05), ϕErgonomics quiz assessment for G2 from Baseline to ASS1 until ASS2 (p<0.05), τErgonomics quiz assessment for Cx from Baseline to ASS1 until ASS2 (p<0.05)

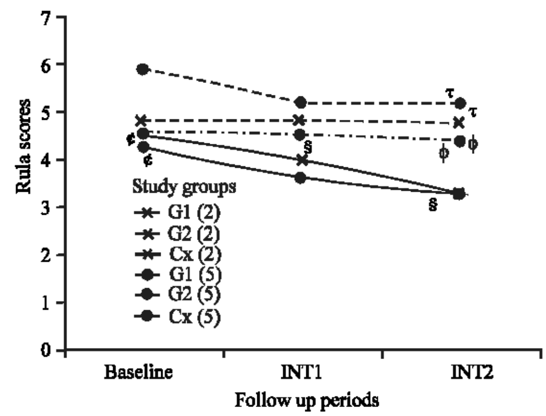

Fig. 5: Repeated GLM of RULA score among 2nd and 5th grade, ¢RULA score baseline taken immediately after implementing the ergonomic furniture for G1, §RULA Scores for G1 from Baseline to ASS1 until ASS2 (p<0.05), τRULA Scores for G2 from Baseline to ASS1 until ASS2 (p<0.05), ϕRULA Scores for Cx from ASS1 to ASS2 (p<0.05)

However, outcome from this study as compared to that observed by Yanto *et al.* (2008), who reported most of the 2nd grade (11-12 years) school children in Indonesia reported as having higher thigh pain (>30%). The strongest complaints in this intervention study were observed in the neck, upper back and low back pain. Jones *et al.* (2003) concluded that the adult musculoskeletal pain complaints may relate to childhood somatic symptoms.

Mikkelsson *et al.* (1997) showed that 30.5% of children in their study reported headache at least once a week compared with 54% of children who also reported musculoskeletal pain. This study suggested one important parameter is to evaluate the knowledge of school children after implementing the intervention programs. From this study, the score increase rapidly among G1 and G2 as suggests that the intervention programs among G1 and G2 showed progressive increment in the term of awareness of ergonomic risks exist in the school. Therefore, based on different studies (Heyman and Dekel, 2009; Schwartz and Jacobs, 1992; Balague *et al.*, 1996) had shown that in the wake of a short-term intervention program, the children's knowledge in these subjects grew. Furthermore, based on other findings, much effort has therefore been invested in recent years in the introduction of ergonomic program for workers, in order to improve the workers functionality and reduce work-related injuries (Marras, 2005). From this ergonomic quiz researchers ound that ergonomic

Table 4: Bag weight measurement for 2nd and 5th grades of three groups

	2nd grade					5th grade				
Variables	Group 1 (n = 37)	Group 2 (n = 38)	Group 3 (n = 35)	F (ANOVA)	Sig.	Group 1 (n = 39)	Group 2 (n = 40)	Group 3 (n = 40)	F (ANOVA)	Sig.
Bag weight measurement										
Baseline bag weight	4.52±0.75	4.79±0.98	4.57±1.31	1.55	0.218	4.24±1.32^	5.86±1.22^	4.57±1.24^	20.28	<0.001**
ASS1 bag weight	4.00±0.69*	4.88±0.96	4.56±1.22	7.85	0.001	3.61±1.39*	5.17±1.35*	4.39±1.29	13.21	<0.001
ASS 2 bag weight	3.28±0.53*	4.74±0.72	4.43±0.90	0.71	0.495	3.23±1.54*	5.18±1.32	4.37±1.21	18.36	<0.001

^The bag weight of the students include everything from home (food, beverages and stationeries) **p-value a cross are comparing mean between G1, G2 and Cx, *Significant using paired t-test from baseline to ASS1 until ASS2, Cx is a control group. Values are expressed as mean±SD

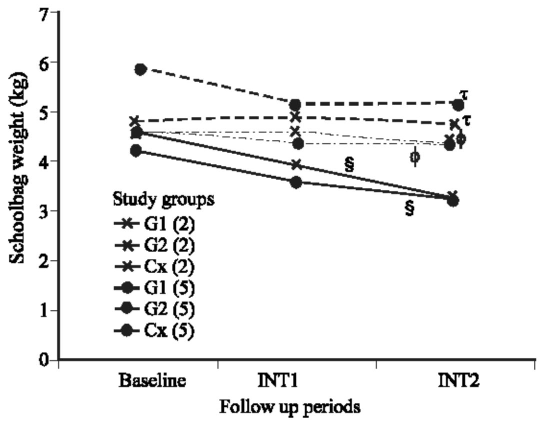

Fig. 6: Repeated GLM of school bag weight among 2nd and 5th grade, §School bag weight for G1 from Baseline to ASS1 until ASS2 ($p<0.05$), ϕSchool bag weight for G2 from Baseline to ASS1 until ASS2 ($p>0.05$), τSchool bag weight for from Baseline to ASS1 until ASS2 ($p>0.05$)

programs faced two common inherent difficulties) incorrect movement patterns and habits become firmly entrenched over the years and difficult to be altered by short-term programs especially among school children because of the maturity rate in which this study found that the difficult in maintaining the knowledge among the 2nd grade (8 years old) compared to 5th grade (10 years old) and due to the fact that learning of proper body function and correct movement patterns is a prolonged process as discuss by previous researchers stated that long-term program is needed to generate in-depth behavioral change among school children (Breithecker *et al*., 2000), the postural damage is caused by the modern sedentary lifestyle not only at the school environment but also in many other daily routines. Previous study indicates that the watching television and using personal computer can increase risk of developing MSD (Syazwan *et al*., 2009).

Rapid upper limb assessment is an observational method of assessing postural health among human workers (McAtamney *et al*., 1993). From this study, all groups showed significant different of RULA score in the baseline until the end of the assessment two. The RULA score of G1 differ from G2 and Cx because of the data baseline collection taken after the implementation of new ergonomic furniture. From this study, it showed that the ergonomic design furniture from previous study (Nurul *et al*., 2009) can significantly reduce the RULA score indicating the ergonomic furniture can help to modified ergonomic risk to the safer lower level. From the figure in the result, the furniture intervention help reduce the risk of awkward posture among G1 student for 2nd and 5th grades.

In conducting the implementation of new ergonomically design furniture, there were some limitation of observing the RULA scores. Because of the effect of posture majorly influence by the furniture design (Lea *et al*., 2009), this may lead to proper sitting posture with lower risk of performing awkward position. As the result, in the baseline data collection itself, the RULA scores among G1 showed huge differences when compared to others two groups (G2 and Cx). Generally, when RULA score increases, it showed high risk of awkward posture perform among the observe respondents. Study showed that the Intervention Programs (IP) help to reduce RULA score thus showed IP able to reduce risk of incorrect posture.

From study of research related injuries, this study showed same result after the implementation of ergonomic intervention programs, where the school children were being taught on the instruction of using the ergonomic furniture design (Paolo Pillastrini *et al*., 2007). Result showed that after the intervention program (INT1 and INT2) among G1 and G2 groups, the RULA scores decrease 24.4 and 23.8% for each groups, respectively. For G1, result indicated that the education of using the ergonomic design furniture must be one important component to encourage the school children on the using of the ergonomics furniture and its design effectively able to reduce ergonomic risks in schools. As showed by the previous researchers, the ergonomically design furniture with comfort curve and arm support increased the upright, neutral back and neck posture during sitting at school lessons compared to conventional workstations (Lea Saarni *et al*., 2009). On the other hand, for G2 groups, the

RULA scores always shows the decreasing pattern indicating that the ergonomic risk had been modified, however, the reduction of awkward posture is still unable to meet the safer level (1 and 2) as compared to G1 groups. Score of RULA indicate that the score of 1 and 2 are the safer level explained that the posture perform is acceptable if it is not maintained or repeated for long periods, while score of 3 and 4 indicate further investigation is needed same with score of 5 and 6, which add up with the changes required to altered the posture perform. The score of 7 explain that the investigation immediately needed and changes required as soon as possible.

From this study however, the major components of the ergonomic risk education had been identified, where the key component of demonstrating and exercising among the school children were the important components in reducing ergonomic risk among school children. This idea of educating trough the demonstrating and exercising appear to be the same findings as showed by Heyman and Dekel (2009), where they stated that the two important philosophy of ergonomic education in school environment, the ergonomic movements and posture.

Schoolbag weight result showed that the mean of 4.24 kg (SD1.32) to 5.86 kg (SD1.22) for all study groups. From the result of this study, it showed that the ergonomic intervention programs among G1 and G2 significantly reduce the schoolbag weight of the school children. The G1 showed significant reduction of schoolbag weight carried by the school children. This suggested that the new ergonomically design furniture help in reducing the bag weight as compared to G2 and Cx groups. This study also showed significant reduction of schoolbag weight after follow up in the assessment two for both groups. This indicates that the IP among G1 successfully reduce ergonomic risk of MSD for bag weight among school children. For G2, the reduction of schoolbag weight was only observed among the 5th group where only 11.8% of the schoolbag weights were reduces from the baseline data collection.

This suggested that the intervention program by health promotion cannot promote and give a longer impact to the school children in educating and promoting lighter schoolbag load to school. Several researchers reported a significant relationship between musculoskeletal pain and school bag weight (Viry *et al*., 1999; Whittfield *et al*., 2005) however, the findings in this study were inconclusive because of the timetable issues and lack of storage area in school.

These of the factors that cannot be control by implementing health promotion program without additional ergonomic implementation. From this study, researchers suggested that the storage area plays a major role in reducing the schoolbag weight as one important ergonomic risk among school children. This is proved by the comparison of bag weight G1 and G2 intervention programs.

CONCLUSION

This study revealed that the ergonomic risk factors of musculoskeletal disorder can be modified to safer level using ergonomic approach intervention programs with ergonomically design furniture.

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